International Journal of Engineering Education Vol. 39, No. 6, pp. 1542–1555, 2023
Printed in Great Britain

0949-149X/91 $3.00+0.00

Designing Elementary Digital Game-based Engineering Interventions for Rural and Indigenous Students*

AMANDA OBERY[1,**], NICHOLAS LUX[2], and PAUL GANNON[3]
[1] Department of Education, Development, Teaching, and Learning, Central Washington University, 400 E. University Way, Ellensburg, WA 98926, USA. E-mail: amanda.obery@cwu.edu
[2] Department of Education, Montana State University, P.O. Box 172880, Bozeman, MT 59717-2880, USA.
E-mail: Nicholas.lux@montana.edu
[3] Department of Chemical and Biological Engineering, Montana State University, PO Box 173920, Bozeman, MT 59717-3920, USA.
E-mail: pgannon@montana.edu

Investigating how elementary students see themselves as engineers will help researchers and educators more clearly develop effective engineering education interventions. With early interventions, students can begin the process of developing an engineering identity, and possibly diversify the field in the future. This study investigates how elementary students from rural contexts and on an Indigenous Reservation view engineering as a basis for the design of identity-congruent digital games. Data was collected through surveys and drawings and used to create a framework for early engineering education interventions using identity-congruent digital games. Results suggest a nuanced understanding of engineering identity being possibly influenced by contextual factors such as gender, rurality, and indigeneity. These findings provide insight into how educators and digital game developers might create engineering interventions based on how students in rural and Indigenous contexts view engineering.

Keywords: engineering education; digital game based learning; elementary; identity based motivation; rural; indigenous

1. Introduction

Research with elementary students indicates that their views of engineers and engineering is often underdeveloped or inaccurate [1]. Increasing evidence suggests that students who do not form an engineering identity at an early age do not pursue engineering careers [2]. Social, cultural and gender norms can challenge engineering identity formation, especially in underrepresented minority students (e.g., rural and Indigenous) and in young females [3]. There is a need to understand the roles that students' educational experiences play in shaping their views of engineering and engineering identity [4]. Promisingly, engineering identity development has been shown to improve with engineering education interventions as early as first grade [5].

One approach to providing opportunities for engineering identity development could come with the integration of digital game-based learning (DGBL). DGBL has been shown to be motivational in educational settings [6–10]. Using digital games in engineering education is a relatively new application, but is quickly gaining attention due to the lower cost of devices and the interactive nature of gaming [11, 12]. Both Bodnar et al. [13] and Udeozor et al. [12] have produced positive reviews on the use of game-based learning in engineering education; however, both reviews target higher education. Very few studies explore the nature of digital game-based approaches for engineering education specific to elementary students [14]. Therefore, exploring elements of digital games for engineering that can capitalize on the positive outcomes seen in higher education settings [e.g., 13] may provide a novel way to support elementary students' understanding and connection with engineering.

2. Review of Literature

"We've always been engineers," said J-man, an Indigenous engineering undergraduate, in response to a question on how familiar students are with engineering [15, p. 675]. This sentiment stands in agreement with Tribal elders and Tribal College and University faculty and administrators [16], who noted various historic Indigenous structural, mechanical, and agricultural achievements. While this sentiment was shared more than 15 years ago, much work remains to meet the National Academy of Engineering's call to diversify the profession, including "the perspectives of American Indians . . . [especially given that] reservations need the culturally relevant contributions of American Indian engineers" [16, p. 7]. Less than a tenth of a percent of college graduates with engineering degrees between 2003–2019 were Indigenous [17]. Hence, fostering engineering identity in Indigenous students requires systematic shifts in the educational system beginning in K-12 [18].

Though millions of students are raised in rural communities and one-fifth of public schools are in

** Corresponding author.

* Accepted 28 August 2023.

rural areas [17] much less attention in research focuses on these communities and people. Companies in rural areas are seeking a skilled workforce, including engineers, yet recruiting remains challenging [19]. Persistent barriers, including geographic isolation, funding, equipment, and finding qualified teachers, exist in many rural areas [20, 21]. These barriers limit the ability to offer engineering programs and enhance the future potential engineering workforce.

Increasing evidence suggests that students who do not form an engineering identity at an early age do not pursue engineering careers. This may be particularly true for female students. Research indicates a gender divide, particularly with minority students, wherein females are less likely to be interested and pursue engineering fields [4, 22, 23]. Research by the American Association of University Women Educational Foundation [24] shows that girls already start to lose interest in engineering around the age of twelve. Therefore, ensuring rural and Indigenous schools have access to interventions that foster interest and connection with engineering, such as those offered through DGBL, are even more important in elementary grades.

2.1 Engineering Identity

Although research has focused on learners' identity formation in science, researchers have begun looking at identity formation specific to engineering [5]. Engineering identity is defined in terms of a potential possible self, and is the degree to which one can view themselves in the future as an engineer [25, 26]. Further, a strong engineering identity impacts a student's ability to continue through difficult engineering tasks, both in K-12 and higher education settings [27]. Capobianco et al. [27] suggests that engineering identity is comprised of three interrelated constructs that can be used as lenses by which to understand one's engineering identity in a given context (p. 700): Students must feel valued in both their academic and social environments (academic identity), understand the nature of engineering and what engineers do (occupational identity), and show interest in setting goals around engineering in the future (engineering aspirations). However, at a given time and context, one or more of these constructs are fluid. Some children may not feel connected to their academic context. But because of other factors [e.g., role models, 28] and an understanding of engineering, they may still aspire to engineering in the future and have strong engineering identity.

Efforts in measuring engineering identity include student drawings [29] and surveys [27], both validated for young adolescents. Based on the 'Draw a Scientist Test,' a long-standing tool to uncover student's ideas about scientists, the 'Draw an Engineer Test' [DAET, 29] has both open-ended questions and asks students to draw an engineer at work. The tool helps students share their views of engineering and engineers. These ideas are critical to a nuanced understanding of the occupational aspect of engineering identity, as the stereotypes, misconceptions, or limited conceptions of engineering will impact the degree to which students identify with engineering or as possible engineers. To account for the social and contextual nature of identity development, the Engineering Identity Development Scale [EIDS, 27] was developed. The EIDS scale is a series of 20 questions, validated for grades 3–5. There is also a contextual nature of our selves [30] suggesting elementary students' development of an engineering identity is woven into the context of school and social community underscoring the role of academic identity in developing a sense of and aspiring to engineering.

Educators should consider including engineering identity-based interventions because of both the need to foster a connection with engineering early and the role that the school and social context play in identity formation [31]. Early interventions are critical [32–34] where the pre-middle school years are essential for supporting a STEM interest. Many differences can be noted in earlier school years, such as attitudinal differences based on mathematics by kindergarten [35]. Gendered attitudes toward mathematics, a discipline integrally related to engineering, are evident by kindergarten [35]. Fortunately, engineering identity development has improved with engineering education integration into elementary grades as early as first grade [5].

2.2 Identity-based Motivation

Identity is a multi-faceted self-concept constructed in contexts in which learners find themselves embedded. Further, research indicates that people prefer identity-congruent behaviors over identity-incongruent behaviors, that is, behaviors in alignment with one's reality versus behaviors that are at odds between how one sees oneself and how one wishes to be [36]. For the purposes of this study, the term "identity" is operationalized as a construct that represents one's sense of self and refers to the combination of personal traits, characteristics, social relationships, and group memberships that a person uses to define who they are and who they might become [37, 38].

Small educational interventions can have large positive effects on identity development when employing integrative frameworks that are culturally sensitive, consistently salient and identity-congruent [39]. One framework to help better understand identity development is identity-based motivation (IBM). The IBM model establishes that we have current identities, or the identities one holds now, and possible identities, or the identities one can see themselves holding in the future [36]. Research suggests that learners need opportunities to align their future identities with their current identities. Further, children can be challenged to see the connection between their current "me" with their future "me," especially when they are unable to see relevance in their future "me" [37]. IBM also helps explain when and under which conditions people look to their identities to provide motivation to take action toward goals [37].

When applying the IBM framework in educational settings, one assumes identities are dynamically constructed in context. Learners' specific identities influence their motivations in specific contexts, which contribute to how learners shape their identities [40]. IBM helps explain how and when cues in sociocultural contexts affect identity formation processes. For example, students might perceive tasks in academic contexts as either important and meaningful or pointless and "not for people like me" [39]. There are also positive impacts of using cultural assets in educational experiences for minority students as those assets enable students to connect to their ways of being (e.g., behaviors, beliefs, preferences). Thus, the contexts have salience and meaningfulness for the students [41, p. 545]. To create congruent and asset-based experiences, researchers and designers must work collaboratively with those who understand the culture and students' "ways of being" [41], or the "ways in which people know, come to know and understand knowledge" [42, p. 3].

Oyserman and Destin [39] suggest three core postulates underscore identity-based motivation processes: action readiness, dynamic construction, and interpretation of difficulty. Action-readiness suggests that identities provide cues for us on how to act and to "make sense of the world in terms of the norms, values, and behaviors relevant to the identity" (p. 177). Dynamic construction means that identity and the behaviors we exhibit are congruent with and shaped by context. And lastly, interpretation of difficulty suggests that when a behavior is interpreted as identity-congruent, the difficulty and effort put into that behavior will be interpreted as meaningful and with merit. Combined, these IBM postulates show why identities and perceptions of self are seen as stable, but are actually flexible and adjusted in context [39].

2.3 Framing Engineering Digital Game-based Interventions Around Identity

Studies on educational digital game-based learning (DGBL) have shown promising impacts on student learning and career interests [43]. It should be noted that in some cases, the term DGBL is used synonymously with the term "serious games." While many examples of DGBL are designed for application in formal learning contexts and oriented entertainment with some educational benefits, "serious games" integrate educational content within the gameplay and are instead designed to support learning in a variety of contexts such as trainings or marketing [44, p. 2]. Video games can engage effective learning paradigms, including experiential learning, inquiry-based learning, self-efficacy, goal setting, cooperation/team learning, and all with continuous feedback and tailored instruction [45]. Additionally, playing video games has been demonstrated to increase dopamine in human brains, which is critical in memory [46]. Although not much research exists on the influence of DGBL on learning in engineering specifically [6], researchers have found that DGBL can have a significant impact on students' content knowledge in other STEM disciplines, such as mechanical engineering and genetics [47–48].

Though the efficacy of DGBL has been demonstrated in elementary education [49], the limited research on DGBL and engineering education has mainly focused on secondary and higher education contexts. Some of this research connects the use of digital games to increased STEM career motivation [50] at the secondary level with fewer studies pointing to this connection at the elementary level specific to engineering [51]. Research indicates that games that address particular STEM skills within particular disciplines could be seen of value by learners when the skills might be applied to engineering careers [6]. Depiction of characters in games can also have an impact on interest in STEM careers. Digital representations of scientist characters and stereotyping in games can have an influence on students, especially young female learners, interest in STEM careers [7]. Other studies have found that culturally responsive approaches to game design can be used to help students reflect on how gaming is relevant to STEM and STEM-related careers, especially in engineering and computer science fields, and could be used to build opportunities to broaden participation for underrepresented students in STEM careers [52]. However, DGBL may be most effective at the elementary level due to the increased emphasis on play in the younger grades [53], and it has shown to promote active learning at this age [54]. Researchers conclude that a thoughtful combination of cognitive, motivational, affective, and sociocultural perspectives are necessary for both game design and research to fully capture what games have to offer for learning [55].

IBM-guided DGBL experiences offer opportunities to build engineering identity through identity congruent engineering interventions within elementary engineering education. For example, research has found that DGBL can provide learners opportunities to identify how they may handle situations faced by an engineer, such as relying on leadership and teamwork skills [56]. In many ways, these findings correspond with the research on IBM, which suggests the need to help learners find congruency between their current self and future self [39]. Further, the customizability and personalization of DGBL introduces other advantages to educators looking to create congruent experiences. The personalization capacity of DGBL could be leveraged by game designers to develop game play interfaces and avatars that are customizable by different users [7].

In Fig. 1, we propose a conceptual framework that builds upon [57] work conceptualizing IBM-framed classroom interventions. We see considerable potential in using DGBL approaches coupled with IBM theory to frame the development of effective engineering education interventions for upper elementary students. This DGBL/IBM-framed learning environment provides opportunities for productive failure [58] and would address engineering identity and engineering in a prosocial, identity-congruent fashion.

2.4 Purpose

Investigating the "ways of being" [41] that shape how elementary students' see themselves as engineers will help researchers and educators more clearly develop effective engineering education interventions. In turn, these interventions can assist educators in better supporting more robust and accurate conceptions of engineers, engineering, and its pro-social nature, and promote the inclusive development of unique engineering identities among elementary students. These efforts could help diversifying the field. Consequently, this study was designed to investigate how elementary students from different educational settings, including rural contexts and on an Indigenous Reservation, view engineering as a basis for the construction of identity-congruent digital games. We developed the following research questions:

1. How do elementary students from different sociocultural contexts and genders view engineers and engineering?
2. How can engineering identity be fostered for rural and Indigenous elementary students through identity-congruent educational interventions such as digital games?

3. Methods

This convergent-parallel mixed methods study, wherein both quantitative and qualitative data is collected simultaneously, [59] aims to connect with two understudied populations, rural and Indigenous students, and better understand their views concerning engineering. The convergent-parallel nature of the design is appropriate given the rich detail afforded by drawings in the DAET, especially given the age of the participants [60], and the promise of the EIDS. Further, as the intent is to establish a foundational understanding of student's views of engineering, completing both the drawings and survey questions simultaneously helped to minimize bias from the researchers.

3.1 Participants

Participants in this study come from four classrooms in rural and Indigenous Reservations in the Northern Rocky Mountains. One of the classrooms is in an Indigenous language immersion school on a Reservation (pseudonym AI1; 11 students) and another is located in a rural location (under 2,000

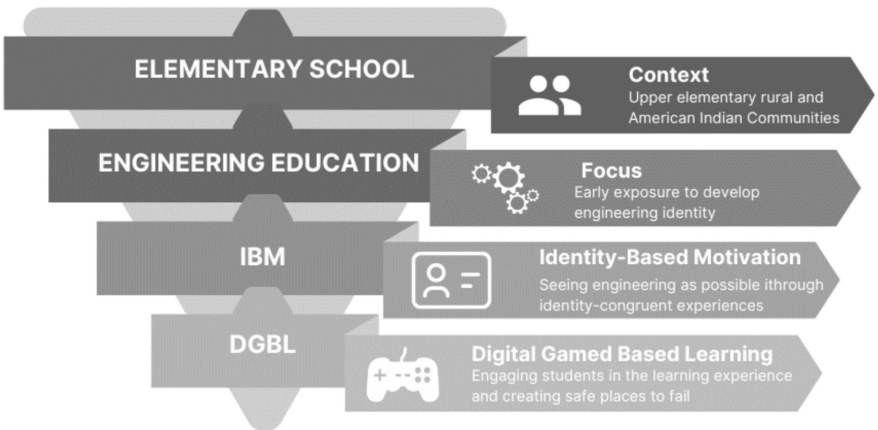

Fig. 1. Overview of an IBM-framed Engineering Classroom Interventions Using Digital Game Based Learning.

residents) on the same Indigenous Reservation (pseudonym AI2; 18 students). The third (pseudonym R1; 28 students) and fourth classroom (pseudonym R2; 25 students) are located in a city (around 50,000 residents) outside of (not bordering) the Reservation. Participants (N = 83) were all enrolled in the 5th grade and aged between nine and 11 years. Of the students, 48% self-identified as male and 52% self-identified as female.

3.2 Data Collection

Data sources for this study included the DAET [29] and the Grades 3-5 EIDS [5]. The DAET consists of open-ended questions about career aspirations, engineering definitions, and an area for students to draw a picture of an engineer at work with a text box to describe the drawing. The EIDS has 20 questions regarding engineering and student identity with responses ranging from "No (1)" to "Yes (3)." Examples of these questions include: "I like being a student at my school," and, "When I grow up, I want to design different things." The EIDS has been validated for use in upper elementary grades [5, 27]. All data collected were masked to ensure students' confidentiality.

3.3 Data Analysis

Once these mixed data were collected, results were entered and analyzed by a team of researchers to ensure trustworthiness and reliability. The EIDS survey was entered into Stata [61] and descriptive statistics, confirmatory factor analysis, and ANOVAs were run to explore intersections of engineering identity to the individual classrooms and student gender. The DAET was entered into NVivo [62], a qualitative data analysis software, and then underwent several rounds of analysis, following the extensive protocols established by Weber et al. [63] and Newley et al. [64]. Four different researchers coded the data independently, met to discuss codes and themes, and came to consensus on the analytic structure suggesting trustworthiness [65].

Themes and constructs arising from both the quantitative and qualitative data sources were then combined in NVivo, wherein the results from the EIDS were matched with the coding from the DAET by student and school. Using processes similar to an explanatory matrix [66], connections and outcomes between views of engineering and future aspirations along intersections of context and gender were explored using analysis features present in NVivo. For example, responses on individual EIDS items were cross tabulated with the types of drawings made on the DAET to look for commonalities and areas of disagreement in how students responded to these tools.

4. Results

First, results from the individual data collection tools (EIDS and DAET) will be presented. Afterwards, intersections between the two tools will be presented.

4.1 Engineering Identity Development Scale (EIDS)

Table 1 presents the combined descriptive statistics and factor structure for all classrooms on the EIDS.

Correlations between variables were moderate ($r = 0.20$–0.60, $p < 0.05$) with one exception between 'When I grow up, I want to be an engineer,' and 'When I grow up, I want to work on a team with engineers' ($r = 0.74$, $p < 0.05$). A confirmatory factor analysis with maximum likelihood estimation was conducted on the data using the three-factor structure [67, see Table 1]. Several items were dropped due to non-significant or poor loading coefficients (e.g., lower than 0.3; items 2–4, and 12 were dropped). All other EIDS items significantly loaded onto three latent constructs (Academic Identity, Occupational Identity, and Engineering Aspirations), with significant loadings ranging from 0.26 to 0.87 ($p < 0.05$). The best fit was obtained using a three-factor model (see Table 2).

Cronbach's alpha for the revised survey was α = 0.79. Variables were created representing the three latent constructs by averaging the item scores that were retained in each of the three factors (see Table 3), in line with previous research conducted by Capobianco et al. [67].

These new variables were then explored for differences between contexts and by gender. A multivariate analysis of variance was conducted to determine the differences between schools and gender on the three dependent variables (academic identity, occupational identity, and engineering aspirations). Significant differences were found among the different genders ($\Lambda = 0.82$, $F(3, 62) = 3.63$, $p < 0.05$, $r^2 = 0.18$) and schools ($\Lambda = 0.53$, $F(6, 98) = 6.13$, $p < 0.05$, $r^2 = 0.27$). Males reported higher levels of "Occupational Identity" ($M = 2.83$, $SD = 0.24$) than females ($M = 2.62$, $SD = 0.35$) though the effect size is small, $r^2 = 0.11$. No other differences were noted by gender on the latent variables.

A significant difference between AI2 and R2, was found for 'Occupational Identity' by follow-up one-way ANOVA, $F(3, 79) = 3.18$, $p < 0.05$, partial eta = 0.11). A Bonferroni post hoc test revealed that AI2 ($M = 2.6$, $SD = 0.39$) was significantly lower than R2 ($M = 2.88$, $SD = 0.24$, $p < 0.05$). Significant differences on 'Engineering Aspirations' were detected between the schools on an Indigenous Reservation and the rural school ($F(3, 79) = 9.26$

Table 1. Descriptive Statistics and Confirmatory Factor Structure on EIDS Items

Survey Item	**Mean**	**Std. Dev.**
1. I do my school work as well as my classmates.[1]	2.58	0.59
2. I am good at solving problems in mathematics.	2.44	0.70
3. I am good at solving problems in science.	2.40	0.60
4. I use computers as well as my classmates.	2.68	0.62
5. I am good at working with others in small groups.[1]	2.62	0.67
6. I like being a student at my school.[1]	2.63	0.62
7. Being a student at my school is important to me. [1]	2.48	0.72
8. I make friends easy at my school. [1]	2.50	0.65
9. The teachers at my school want me to do well in my school work.[1]	2.85	0.45
10. Engineers solve problems that help people.[2]	2.68	0.56
11. Engineers work in teams.[2]	2.76	0.48
12. Engineers design everything around us.	2.24	0.76
13. There is more than one type of engineer.[2]	2.78	0.52
14. Engineers use mathematics.[2]	2.79	0.44
15. Engineers use science.[2]	2.86	0.39
16. Engineers are creative.[2]	2.75	0.53
17. When I grow up, I want to be an engineer.[3]	1.80	0.82
18. When I grow up, I want to solve problems that help people.[3]	2.38	0.73
19. When I grow up, I want to design different things.[3]	2.31	0.82
20. When I grow up, I want to work on a team with engineers.[3]	1.98	0.82

Note. Item scale is 1–3, with 3 being the highest rating.
[1] Item factors with Academic Identity.
[2] Item factors with Occupational Identity.
[3] Item factors with Engineering Aspirations.

Table 2. Summary of Confirmatory Factor Analysis Results

	χ^2	df	CFI	TLI	RMSEA	90% CI	SRMR
3 Factor Model	170.56	101	0.79	0.74	0.09	(0.07, 0.12)	0.11

Note. CI = confidence interval; CFI = Comparative Fix Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual

Table 3. Descriptive Statistics for Engineering Identity Latent Constructs

New construct	**Mean**	**SD**	**Minimum**	**Maximum**
Academic Identity	2.61	0.37	1.17	3.00
Occupational Identity	2.77	0.30	1.50	3.00
Engineering Aspirations	2.11	0.64	1.00	3.00

$p < 0.00$, $r^2 = 0.26$). Bonferroni post hoc testing shared that the two Indigenous schools (AI1: $M = 2.65$, $SD = 0.43$; AI2: $M = 2.44$, $SD = 0.45$;) had significantly higher 'Engineering Aspirations' than both of the rural schools (R1: $M = 1.94$, $SD = 0.60$; R2: $M = 1.79$, $SD = 0.65$). However, no differences were found between AI1 and AI2 nor between R1 and R2 schools, suggesting a difference between these two contexts rather than within the contexts.

No significant differences were detected in terms of "Academic Identity."

4.2 Draw An Engineer Test (DAET)

Results from the DAET will be organized by the questions relating to career aspirations and then by students' drawings of engineers at work.

4.2.1 Career Aspirations

Following Newley's [64] approach, responses to the initial question on the DAET, "What type of job or jobs do you think you might want to do 'when you grow up'?" were organized into STEM and Non-STEM careers. Thirty-six non-STEM careers (e.g., artist or President) and 30 STEM careers were described (e.g., nurse or farmer). As for the second question, "When you hear the word 'engineer', what do you think about?", responses were organized into five categories, three from Newley [64] (laborer, mechanic, designer), and an additional category of "don't know engineering," see Table 4. Table 4 shows the proportion of students who shared that engineers are either builders,

Table 4. Student responses to what comes to mind with the word 'engineer' by school and gender

Category	School			Gender		
	AI1	AI2	R1	R2	Female	Male
Builder/Laborer	19.0%	14.3%	47.6%	19.0%	40.0%	60.0%
Designer/Maker	5.0%	22.5%	22.5%	50.0%	44.7%	55.3%
Fixer/Mechanic	13.8%	31.0%	27.6%	27.6%	48.3%	51.7%
Don't Know Engineering	27.3%	36.4%	27.3%	9.1%	90.9%	9.1%

Table 5. Descriptive Statistics for the EIDS Latent Constructs by the "Yes/No" Response on the DAET

	No		Yes	
	Mean	SD	Mean	SD
Academic Identity	2.41	0.57	2.71	0.29
Occupational Identity	2.59	0.33	2.86	0.23
Engineering Aspirations	1.94	0.12	2.56	0.08

designers, fixers, or that they don't know what an engineer is, by school and gender.

Many of the responses about what the word "engineer" brings to mind did not show large differences between males and females. One new category arose from students saying, "I do not know it," in response to being asked what an engineer does. The exception being that all but one of the students who responded "Don't Know Engineering" were female.

When asked whether or not they had thought about becoming an engineer, females (24.3% responded "Yes") were less likely to have thought about engineering than males (60% responded "Yes"). Students who said that they had not thought about being an engineer were 1.6 times more likely to describe career aspirations towards the non-STEM fields than those who said they had. However, when students said they had thought about being an engineer, they were 1.3 times more likely to describe career aspirations towards the STEM fields.

In addition to selecting "Yes/No" on thinking about being an engineer, students were asked to provide a rationale for their decision. Several noted sentiments such as "because I want to help others," and, "helps [*sic*] pepol [*sic*] evrey [*sic*] day," and these students drew images depicting a varied array of engineering actions such as construction, drawing, fixing, and making. However, there were students whose rationale contained sentiments such as, "Working on cars seems like a lot of work," and, "because it looks hard," and they only drew actions related to engineers being fixers.

4.2.2 Drawings

When asked about the word, "engineer," 28% of responses suggested that these were people who were fixers (e.g., mechanics and technicians), 24% of responses saw engineers as those who design or create, and 23% envisioned engineers as builders or laborers. Of these responses, there may be differences based on whether or not students can see themselves as engineers.

Findings indicate that rural and Indigenous students' views of engineers display gender differences, in alignment with previous similar studies [4]. In analyzing female students' drawings of engineers, 52% were female engineers, 33% were male engineers, and 15% gender neutral. This is in comparison to male drawings of engineers, 0% of which were female, 77% were male, and 23% were gender neutral.

4.3 Connections between EIDS and DAET

Considering points of intersection between the two data sources can act as a measure of validity and can highlight important results. NVivo [62], the qualitative data analysis software used, records instances of coding on a given data source and provides analytics that allow for cross tabulation between datasets, such as results from the EIDS and how a students responded on the DAET. For example, about 80% of students who responded "no" to the DAET question (as coded in NVivo) on whether or not they thought about engineering also responded 'no' or 'not sure' to becoming an engineer or working on a team with engineers in the future on the EIDS (dataset uploaded to NVivo). Thus, on this intersection students can be seen to respond similarly on both survey instruments. The cross tabulated data can be analyzed for trends between constructs on different instruments.

Table 5 outlines the relationship between how students responded to thinking about being an engineer (yes/no) on the DAET and the latent constructs uncovered in the EIDS (academic identity, occupational identity, and engineering). Descriptive statistics are provided for the latent constructs on the EIDS by the students "yes/no"

Table 6. Descriptive Statistics for the EIDS Latent Constructs by the STEM or Non-STEM Aspirations Shared on the DAET

	Non-STEM		STEM	
	Mean	SD	Mean	SD
Academic Identity	2.58	0.45	2.68	0.30
Occupational Identity	2.68	0.35	2.79	0.23
Engineering Aspirations	2.16	0.60	2.46	0.52

responses to thinking about engineering responses on the DAET, see Table 5. Results show higher reported engineering identity overall when students responded positively to thinking about engineering. Further, given the differences in means, results add credence to the notion that students can learn (academic identity) and know engineering principles (occupational identity) in school without aspiring to an engineering career in the future [67, p. 52].

Results show higher reported engineering identity overall when students responded, Table 6.

Interestingly, when comparing those students who shared non-STEM or STEM career aspirations with their scores on the engineering identity constructs, there was a difference. Those who shared STEM job interests had significantly higher scores on engineering aspirations (M = 2.44, SD = 0.27) than those who talked about non-STEM jobs (M = 2.16, SD = 0.35) on the DAET. A two-sample t-test showed that these means were significantly different, t (65) = 1.67, p < 0.05. Students also shared that they did not know what engineering was in response to the career aspirations question on the DAET and these students had high academic identity (M = 2.83, SD = 0.28).

On the DAET, students also described what engineers do. Those students who talked about engineers as designers or makers were more likely to aspire to be an engineer on the EIDS (M = 2.4, SD = 0.80) than those who described engineers as fixers or mechanics (M = 1.76, SD = 0.77). A two-sample t-test showed that these means were significantly different, t (37) = 2.03, p <0.05.

An additional area where connections were made between the EIDS and the DAET is in student drawings from the DAET. The inclusion of people [Category 1, 63] into students' drawings of an engineer at work strongly correlates with students' academic (r = 0.87, p < 0.05) and occupational (r = 0.85, p < 0.05) identity, but not with their engineering aspirations (r = 0.61, p > 0.05). This result suggests that when students understand what engineers do (occupational identity) and feel connected at school (academic identity), these connections may not influence their desire to be an engineer. Also, the human engineered objects [Category 2, 63], which students included in their drawings varied. As students increased in academic identity on the EIDS, their inclusion of buildings, desks, tools, and vehicles increased (r = 0.84 –0.77, p < 0.05), however, this was not the case with the inclusion of technology (r = 0.53, p > 0.05). The same pattern is true for occupational identity, with students' inclusion of buildings, desks, tools, and vehicles all increasing with occupational identity (r = 0.90–0.73, p < 0.05) but not with technology (r = 0.60, p > 0.05). The only human powered component of the drawings that significantly correlated with engineering aspirations was the inclusion of a desk or lab bench (r = 0.68, p < 0.05). These results suggest that students may not connect technology with the discipline of engineering, limiting what they think of as engineering.

When students were asked about their job aspirations on the DAET, they also provided a rationale explaining their thinking. Nine students mentioned that they had thought about becoming an engineer and listed reasons around helping others. These students' academic identity (M = 2.69, SD = 0.47) is similar to the participant average, but the occupational identity (M = 2.83, SD = 0.33) and engineering aspirations (M = 2.44, SD = 0.65) are above average. Finally, in the DAET, students were asked about their job aspirations, their thinking about engineering and to draw an engineer. At various points, eight students brought up personal connections with engineering through family members. These students had high occupational identity (M = 2.78, SD = 0.31) and engineering aspirations (M = 2.40, SD = 0.36), both above the average value of the sample (see Table 3). Thus, there is evidence suggesting that including a prosocial focus and making a personal connection may support developing engineering identity and aspirations.

5. Discussion

The EIDS survey and the DAET tool were implemented in order to understand the current selves of students and their engineering identity. Beginning development of educational interventions with an understanding of students' current engineering identity will enable the actions needed to support future-selves in ways that are both congruent [39] with their "ways of being" [41] and, with DGBL, in spaces where adequate failure is encouraged, normal, and can support student learning [6].

Results from this study provide evidence suggesting that engineering identity and STEM identity are related. While this is intuitive given that engineering is in STEM, results indicate that students engineering identity scores are more likely to share STEM-career based aspirations. Additionally, students were asked if they had thought about becoming an engineer and, when they responded that they had, they were 1.3 times more likely to describe a STEM career aspiration.

5.1 An Approach for Elementary Identity-based Engineering Digital Games

Based on these initial findings from the EIDS and DAET in both rural and Indigenous Reservation schools, our research team conceptualized a DGBL and IBM-framed intervention that provides learners an opportunity to explore and identify with engineering. To build the framework for this intervention, we have integrated our findings from the DAET and EIDS with the core postulates of IBM. Therefore, we suggest that our findings coupled with the previous research on IBM and DGBL provide evidence towards a series of recommendations for a DGBL engineering-focused intervention. The following presents the key findings from the DAET and EIDS and the resulting recommendation for an engineering intervention.

5.1.1 Collaborative and STEM-based Nature of Engineering

Measuring engineering identity (academic identity, occupational identity, and engineering aspirations) revealed that students, have a high sense of academic (M = 2.61, SD = 0.37) and occupational identity (M = 2.77, SD = 0.30) but lower engineering aspirations (M = 2.11, SD = 0.64). Overall, students feel confident in their academic selves and understand the nature of engineering as collaborative and interdisciplinary. *Thus, interventions may not need to focus on the collaborative or STEM based nature of engineering*, and, for example, may allow players to participate in challenges independently.

5.1.2 What Engineers Do

It continues to be important to provide all students, regardless of gender, with an understanding of what engineers do, particularly in light of the DAET drawings and explanations sharing that students "do not know it." *Thus, interventions should address in more detail the intricacies of different engineering fields.*

5.1.3 Builders vs. Fixers

Drawing from results on the DAET, students who see engineers as having an education also feel that engineers are those who build. *Thus, building and construction may not need to be emphasized as students might already make the connection between training, construction, and engineering. However, games may need to reframe how students see mechanics or engineers as fixers* [64], as those students who noted that engineering was difficult only drew pictures containing engineers fixing things such as vehicles.

5.1.4 Personalization and Use of Human Avatars

The inclusion of people [Category 1, 63] into students' drawings of an engineer at work strongly correlates with students' academic and occupational identity, but not with their engineering aspirations. Further, the personalization capacity of DGBL could allow avatars to be customizable by different users allowing students who differ on race, age, and gender to connect to the content and game more strongly [7]. *Thus, for developing academic and occupational aspects of identity, games should include human avatars that should be customizable by learners.*

5.1.5 Gender Inclusivity

In terms of differences by gender, males had higher scores for Occupational Identity than females. Despite the small effect size, and particularly in light of continual research showing a persistent difference between males and females in engineering [68–69]. In addition, no male-identified student drew a women engineer, and female-identified students drew female engineers about half of the time. *Thus, it is still important to ensure that there are female engineers represented in the intervention and game [3].*

5.1.6 Prosocial Nature

There is evidence suggesting that *including a prosocial focus and making a personal connection* may support developing engineering identity and aspiration, as students shared a desire to help others through engineering. *Thus, interventions should include a prosocial emphasis and provide opportunities for learners to connect to engineers' careers in culturally relevant ways.*

5.1.7 Engineers as Designers and Makers

When students responded that they had thought about being an engineer, they drew more images of drawing or making compared to those that said they had not. Further, students who see engineers as designers or makers were more likely to aspire to be an engineer on the EIDS than those who described engineers as fixers or mechanics. *Thus, showing engineers as those who draw or make may be critical to include into games.*

Table 7. Proposed Design for an Engineering-focused IBM-framed DGBL Intervention [39]

Intervention Session	Classroom Activity and DGBL Flow	Take Home Point	IBM Construct
Session 1: Initial Identity Exploration	Students complete the EIDS and DAET. These measurements encourage learners to consider their academic identity and occupational identities, as well as their perceptions of engineering as a profession.	We all have views of our current selves as learners. Further, we all have views of what kind of careers we might pursue as our future possible selves.	DC = Dynamic construction AR = Action-readiness
Session 2: Setting the Stage & Introduction	Students are paired up and briefly interview one another on perceptions of their future selves by discussing the type of job or jobs they think you might want to do when they become adults. They will also discuss the skills or ability they each have that will help them complete attain that career (e.g., "well organized," "positive attitude"). Then each student introduces his or her interview partner in terms of their future plans and skills.	"We all have images of ourselves as adults in the far future", and we have the skills or abilities to work on our future self [71, p.17; 70, p 47–48].	DC = Dynamic construction AR = Action-readiness
Session 3: Engineering Images	Students view a professionally produced video about engineering [e.g., 72]. The video focuses on what it takes to be an engineer and what attracts the high school and college students in the video to engineering. Further, the short video is gender and racially-ethnically inclusive and dismantles some of the misconceptions of engineering such as the discipline is overly difficult and requires considerable math ability. The video also shows engineers as both "builders" and "fixers" [64]. The video also emphasizes that even though engineering is a challenging discipline, anyone can be an engineer and find value in the profession. Following the video, students collaboratively reflect on how they perceive their future identities as engineers.	We all have images of what a "typical" engineer looks like, as well as preconceived notions of what engineering entails, the goals of engineering and what strengths engineers often possess.	DC = Dynamic construction PR = Procedural-readiness
Session 4: Positive & Negative Forces	Students revisit their DAET drawings and add to them by drawing or writing about the positive and negative forces they believe they might face while working toward a career in engineering. This includes addressing the people, things, or actions that could support them as they work toward their possible identity as an engineer.	We all face obstacles and difficulties in school as we work toward becoming an engineer. However, if we set our goals and see congruency between our current self and future identity, the difficulty and effort put into becoming an engineer will be seen as meaningful and not without merit.	DC = Dynamic construction PR = Procedural-readiness
Session 5: Timelines	"Students draw timelines into the future, including forks in the road and obstacles. Since students start with the present, all timelines involve school. Students' timelines culminate" with becoming an engineer [71, p.17; 70, p 47-48].	"Present and future are linked on a path. There are choices and obstacles all will face on that path. Current actions set up which futures in engineering are possible. Obstacles must be gotten around to get back on path" toward becoming an engineer [71, p.17; 70, p 47–48].	DC = Dynamic construction PR = Procedural-readiness
Session 6: Action Goals	Students work individually to conceptualize action goals, or milestones in working toward becoming an engineer. To do this, they will be sure to connect their current self as an elementary student, to a middle school and high school student, to a college student, and finally their engineer possible selves with actions they can take right away in a specific time and place to solidify the plan. "They do this using an easy to recall formula (because... I will... when...)" [71, p.17; 70, p 47–48].	"We have some control over possible selves, but not our hopes and dreams. Control over our possible selves happens when we link the future with the present through specific 'action paths' ways to move to the far future by working now to attain near future goals" [71, p.17; 70, p 47–48].	DC = Dynamic construction AR = Action-readiness
Session 7: Initial DGBL	Students begin gameplay. Primary activities in the session includes personalization through avatar creation where they use their DAET as the basis for constructing their engineering avatar characteristics in a way that demonstrates their possible self as an engineer [7]. Students then team up and face game-based puzzles and problems that initially seem impossible and document the strategies they use to solve those puzzles.	"Difficult things can seem impossible, not worth your time; but difficulty can be a signal of importance. When something feels really difficult, you can use a strategy like breaking it down into parts" [71, p.17; 70, p 47–48].	DC = Dynamic construction AR = Action-readiness PR = Procedural-readiness

Table 7 (*cont.*)

Intervention Session	Classroom Activity and DGBL Flow	Take Home Point	IBM Construct
Session 8: DGBL Engineering Problems	Students complete the engineering activities within the game. The game activities include solving engineering puzzles, as well as exploring a variety of prosocial and cultural connections to engineering. They will work collaboratively, employing leadership and teamwork skills [56] as well as the IBM skills they have learned to consider how to break the problems down. There will be a considerable emphasis in the game play on providing opportunities for the learners to witness cultural and community-based connections between the discipline of engineering, their current selves, and their possible selves.	Engineering problems can be deconstructed skills you already have. You can consider how it relates to your engineering possible self. You can also ''consider what your positive and negative forces are in this situation, you can consider what is the choice point or obstacle in these situations and you can ask what are your strategies to get around it'' [71, p.17; 70, p 47–48].	PR = Procedural-readiness DC = Dynamic construction
Session 9: Wrapping up & Moving Forward	Students reflect on the intervention by naming the different sessions, revisiting what each was about, what they liked about each, and what they would improve if given the opportunity. This gives the learners a chance to reflect holistically on the intervention, provides them closure at completion of the intervention, and a chance for reinforcement of the three IBM components [71, p.17; 70, p 47–48].	''What I do now matters for attaining my next year and adult possible selves. Possible [engineering] selves that are linked to strategies and to a time and a place of action become action goals. There are forks (choices) and roadblocks (failures) along the way. It will be difficult and may feel impossible, but asking questions helps break down what I need to find out and helps me connect to others – positive forces – as well as learn from negative forces what not to do'' [71, p.17; 70, p 47–48].	DC = Dynamic construction AR = Action-readiness PR = Procedural-readiness

5.1.8 Careful Selection of Artifacts of Engineering

The only human engineered object in the drawings that significantly correlated with engineering aspirations was the inclusion of a desk or lab bench. These results suggest that students do not connect technology [63] with the discipline of engineering, limiting what they see as engineering and what is possible to do with engineering (p. 3). *Therefore, when depicting engineers, careful selection of the human-engineered objects, including technology should be taken to allow the diversity of engineering objects to be represented.*

5.2 Conceptualized Intervention Design

In an effort to outline more concretely what the full intervention might include, we have adapted and built upon Oyserman's [71] 12-session School-to-Jobs intervention originally designed as a ''testable, usable, feasible, and scalable intervention for use in schools and other settings to improve academic outcomes'' (p. 33). Our adapted version integrates core components of the School-to-Job intervention [71] but with modifications to address elementary engineering education and use a DGBL approach. Table 7 outlines the proposed intervention framework, aligned to the three core IBM principles: dynamic construction, action readiness, and procedural readiness. We have heavily scaffolded the intervention design, where the first six sessions address engineering identity exploration and development, and sessions seven through nine addressed used DGBL to build engineering identity.

We have operationalized each core IBM principle based on the literature. *Dynamic construction* suggests that significant role of context in our identity, and that the behaviors we exhibit are congruent with and shaped by context. *Action-readiness* suggests that our identities provide the cues used to determine how to act and to make sense of the context [36, 39]. *Procedural-readiness* suggests learners can interpret their experiences as important and possible [71].

5.3 Limitations & Implications

Several factors limit our study. First, the small sample size and specific context of the participants limit the ability to apply the findings to other contexts and STEM disciplines. By no means do the results suggest the understandings of engineering for all rural and Indigenous populations, particularly as many of the claims are based on the average response and thus do not show the diversity present in the sample. Including more perspectives, specifically those from other Indigenous tribes and/or Nations, would certainly add a more nuanced layer to whether identity-based digital games can speak to diverse cultures.

Our design for an identity-based DGBL engineering education intervention are certainly not intended to be considered exhaustive or comprehensive. Further, the methods used in the study could be strengthened with the addition of rich description and context that often come from more open and conversational approaches. The research team relied on validated self-report tools to gain a foundational understanding of pre-intervention views on engineering from fifth grade students. Other tools or methods will invariably add to a collective understanding of whether identity-based digital games can enhance engineering identity.

6. Conclusion

In summary, findings from this study indicate that contextual factors such as such as gender, rurality, and indigeneity influence students' nuanced understanding of engineering identity. Starting from students initial understanding of engineering, games can be designed to support students "ways of being". For rural and Indigenous students, enabling students to engage in individual game play, see a variety of engineering disciplines from a pro-social lens, include women and human avatars that look like them, and ensure that players engage with a variety of human-engineered objects, especially technology, that allows them to draw or make, may offer the best chance to support students seeing themselves as engineers. The game could then be implemented within an identity-congruent series of lessons to best support the connection between their current selves and future selves. The intent is to build insight into how educators and digital game developers can co-develop engineering education interventions that are rooted entirely in how students in Indigenous and rural youth conceptualize engineering.

Acknowledgements – This study was funded by the National Science Foundation, Research into the Formation of Engineers, Award #1825032.

References

1. B. M. Capobianco, H. A. Diefes-Dux, I. Mena and J. Weller, What is an Engineer? Implications of elementary school student conceptions for engineering education, *Journal of Engineering Education*, **100**(2), pp. 304–328, 2011.
2. Microsoft, *Why Europe's girls aren't studying STEM: Region-wide research of 11,500 women reveals how we can get more young women into science, technology, engineering and math.* Microsoft. https://news.microsoft.com/europe/features/dont-european-girls-like-science-technology/#sm.0001pbyasxy2jezvymh2n1jsgoz71, Accessed 17 July 2023.
3. M. E. Denton, I. V. Sabaraya, N. B. Saleh and M. J. Kirisits, The effect of a caring intervention on engineering identity: Insights from a one-day outreach event with elementary and middle school girl scouts, *International Journal of Engineering Education*, **38**(1), pp. 130–144, 2022.
4. M. Liu and F. K. Chiang, Middle school students' perceptions of engineers: A case study of Beijing students, *International Journal of Technology and Design Education*, **30**(3), pp. 479–506, 2020.
5. B. M. Capobianco, J. Yu, and B. French, Effects of engineering design-based science on elementary school science students' engineering identity development across gender and grade, *Research in Science Education*, **45**(2), pp. 275–292, 2015.
6. K. Cook-Chennault, I. Villanueva Alarcón, and G. Jacob, Usefulness of Digital Serious Games in Engineering for Diverse Undergraduate Students, *Education Sciences*, **12**(1), pp. 1–20, 2022.
7. I. Hawkins, R. Ratan, D. Blair and J. Fordham, The effects of gender role stereotypes in digital learning games on motivation for STEM achievement, *Journal of Science Education and Technology*, **28**(6), pp. 628–637, 2019.
8. L. C. Jackson, J. O'Mara, J. Moss and A. C. Jackson, A critical review of the effectiveness of narrative-driven digital educational games, *International Journal of Game-Based Learning*, **8**(4), pp. 32–49, 2018.
9. L. C. Jackson, J. O'Mara, J. Moss and A. C. Jackson, Analysing digital educational games with the games as action, games as text framework, *Computers and Education*, **183**, 104500, 2022.
10. M. Ninaus, S. Greipl, K. Kiili, A. Lindstedt, S. Huber, E. Klein, H. O. Karnath and K. Moeller, Increased emotional engagement in game-based learning: A machine learning approach on facial emotion detection data, *Computers & Education*, **142**, 103641, 2019.
11. C. Bodnar, M. Liauw and T. Sainio, Digitalisation in chemical engineering education and training, *Education for Chemical Engineers*, **36**, 2021.
12. C. Udeozor, R. Toyoda, F. Russo Abegão and J. Glassey, Digital games in engineering education: Systematic review and future trends, *European Journal of Engineering Education*, **48**(2), pp. 321–339. 2022.
13. C. Bodnar, D. Anastasio, J. A. Enszer and D. D. Burkey, Engineers at play: Games as teaching tools for undergraduate engineering students, *Journal of Engineering Education*, **105**(1), pp. 147–200, 2016.
14. C. V. Carvalho, M. Caeiro-Rodríguez, M. L. Nistal, M. Hromin, A. Bianchi, O. Heidmann, H. Tsalapatas and A. Metin, Using video games to promote engineering careers, *International Journal of Engineering Education*, **34**(2), pp. 388–399, 2018.
15. M. Kwapisz, B. E. Hughes, W. J. Schell, E. Ward and T. Sybesma, "We've Always Been Engineers:" Indigenous student voices on engineering and leadership identities, *Education Sciences*, **11**(11), pp. 675–693, 2021.
16. National Academy of Engineering, *Engineering Studies at Tribal Colleges and Universities*, The National Academies Press, Washington D.C., 2006.
17. National Center for Education Statistics, https://nces.ed.gov/pubs2018/2018052/tables/table_04.asp, Accessed 17 July 2023.
18. S. S. Jordan, C. H. Foster, I. K. Anderson, C. A. Betoney and T. J. D. Pangan, Learning from the experiences of Navajo engineers: Looking toward the development of a culturally responsive engineering curriculum, *Journal of Engineering Education*, **108**(3), pp. 355–376, 2019.
19. J. Nixon, A. Stoiber, E. Halverson and M. Dando, Making makers: Tracing STEM identity in rural communities, *Journal of Pre-College Engineering Education Research*, **11**(1), pp. 214–229, 2021.

20. D. Gutierrez, *Little school on the prairie: The overlooked plight of rural education*. Harvard Political Review, 2016.
21. G. C. Nugent, *Rural education research in the United States: State of the science and emerging directions*, Springer, Switzerland, 2017.
22. J. Moote, L. Archer, J. DeWitt and E. MacLeod, Comparing students' engineering and science aspirations from age 10 to 16: Investigating the role of gender, ethnicity, cultural capital, and attitudinal factors, *Journal of Engineering Education*, **109**(1), pp. 34–51, 2020.
23. J. L. Wendt, A. Rockinson-Szapkiw and M. Cordes, Examining the influence of a STEM certification model on female, minority science outcomes, *Journal of Educational Research*, **111**(6), pp. 666–677, 2018.
24. American Association of University Women Educational Foundation, *Tech-savvy: Educating girls in the new computer age*, American Association of University Women Educational Foundation, 2020.
25. Z. Aguirre-Muñoz, M. Pantoya, M. Pando and E. S. Loria Garro, Engineering integration in elementary science classrooms: Effects of disciplinary language scaffolds on English learners' content learning and engineering identity, *Journal of Engineering Education*, **110**(3), pp. 517–44, 2021.
26. B. M. Capobianco, Undergraduate women engineering their professional identities, *Journal of Women and Minorities in Science and Engineering*, **12**(2–3), pp. 95–117, 2006.
27. B. M. Capobianco, B. French and H. Diefes-Dux, Engineering identity development among pre-adolescent learners, *Journal of Engineering Education*, **101**(4), pp. 698–716, 2012.
28. M. McLean, J. M. Nation, A. Spina, T. Susko, D. Harlow and J. Bianchini, The importance of collaborative design for narrowing the gender gap in engineering: An analysis of engineering identity development in elementary students, *Journal of Pre-College Engineering Education Research*, **10**(2), Article 2, 2020.
29. M. Knight, and C. Cunningham, *Draw an Engineer Test (DAET): Development of a tool to investigate students' ideas about engineers and engineering*, Salt Lake City, UT, American Society for Engineering Education Annual Conference & Exposition, 2004.
30. J. Gee, Identity as an analytic lens for research in education, in W. G. Secada (ed), *Review of research in education*, American Educational Research Association, Washington, DC, 2001.
31. J. R. Morelock, A systematic literature review of engineering identity: Definitions, factors, and interventions affecting development, and means of measurement, *European Journal of Engineering Education*, **42**(6), pp. 1240–1262, 2017.
32. R. H. Tai, C. Liu, A. Maltese and X. Fan, Planning early for careers in science, *Science*, **312**(5777), pp. 1143–1144, 2006.
33. D. Vedder-Weiss and D. Fortus, Adolescents' declining motivation to learn science: Inevitable or not, *Journal of Research in Science Teaching*, **48**(2), pp. 199–216, 2011.
34. D. Vedder-Weiss and D. Fortus, School, teacher, peers, and parents' goals emphases and adolescents' motivation to learn science in and out of school, *Journal of Research in Science Teaching*, **50**(8), pp. 952–988, 2013.
35. S. J. Ceci, D. K. Ginther, S. Kahn and W. M Williams, Women in academic science: A changing landscape. *Psychological Science in the Public Interest*, **15**(3), pp. 75–141, 2014.
36. K. C. Elmore and D. Oyserman, If 'we' can succeed, 'I' can too: Identity-based motivation and gender in the classroom, *Contemporary Educational Psychology*, **37**(3), pp. 176–185, 2012.
37. C. Nurra and D. Oyserman, From future self to current action: An identity-based motivation perspective, *Self and identity*, **17**(3), pp. 343–364, 2018.
38. D. Oyserman, K. Elmore and G. Smith, *Self, self-concept, and identity*, in Handbook of self and identity, 2nd edn, The Guilford Press, New York, New York, pp. 69-104, 2012.
39. D. Oyserman and M. Destin, Identity-based motivation: Implications for intervention, *The Counseling Psychologist*, **38**(7), pp. 1001–1043, 2010.
40. A. Godwin and A. Kirn, Identity-based motivation: Connections between first-year students' engineering role identities and future-time perspectives, *Journal Of Engineering Education*, **109**(3), pp. 362–383, 2020.
41. S. T. Coleman, A. W. Bruce, L. J. White, A. W. Boykin and K. Tyler, Communal and individual learning contexts as they relate to mathematics achievement under simulated classroom conditions, *Journal of Black Psychology*, **43**, pp. 543–564, 2017.
42. B. Brayboy and E. Maughan, Indigenous Knowledges and the Story of the Bean, *Harvard Educational Review*, **79**(1), 1–21, 2009.
43. J. Groff, C. Howells and S. Cranmer, *The impact of console games in the classroom*. Learning and Teaching, Scotland, 2010.
44. S. Rosenthal and R. A. Ratan, Balancing learning and enjoyment in serious games: Kerbal Space Program and the communication mediation model, *Computers and education*, **182**, 104480, 2022.
45. M. Mayo, Games for science and engineering education, *Communications of the ACM*, **50**(7), pp. 30–35, 2007.
46. M. J. Koepp, R. N. Gunn, A .D. Lawrence, V. J. Cunningham, A. Dagher, T. Jones, D. J. Brooks, C. J. Bench and P. M. Grasby, Evidence for striatal dopamine release during a video game, *Nature*, **393**(6682), pp. 266–268, 1998.
47. R. Joiner, J. Iacovides, M. Owen, C. Gavin, S. Clibbery, J. Darling and B. Drew, Digital games, gender and learning in engineering: Do females benefit as much as males? *Journal of Science Education and Technology*, **20**(2), pp. 178–185, 2011.
48. A. Rachmatullah, F. Reichsman, T. Lord, C. Dorsey, B. Mott, J. Lester and E. Wiebe, Modeling secondary students' genetics learning in a game-based environment: Integrating the expectancy-value theory of achievement motivation and flow theory, *Journal of Science Education and Technology*, **30**(4), pp. 511–528, 2021.
49. H. Y. Sung, G. J. Hwang, C. J. Lin and T. W. Hong, Experiencing the analects of confucius: An experiential game-based learning approach to promoting students' motivation and conception of learning, *Computers & Education*, **110**, pp. 143–153, 2017.
50. L. M. Miller, C. I. Change, S. Wang, M. E. Beier and Y. Klisch, Learning and motivational impacts of a multimedia science game, *Computers & Education*, **57**(1), pp. 1425–1433, 2011.
51. M. Briscoe, L. S. McCue and D. A Lumme, Implementing and Integrating an engineering video game into a variety of educational contexts, *ASEE Annual Conference & Exposition*, June, 2021.
52. J. K. Newton, J. Leonard, A. Buss, C. G. Wright, and J. Barnes-Johnson, Informal STEM: learning with robotics and game design in an urban context, *Journal of Research on Technology in Education*, **52**(2), pp. 129–147, 2020.
53. H. Lei, M. M. Chiu, D. Wang, C. Wang and T. Xie, Effects of game-based learning on students' achievement in science: A meta-analysis, *Journal of Educational Computing Research*, **60**(6), pp. 1373–1398, 2022.
54. G. J. Hwang, L. Y. Chiu and C. H. Chen, A contextual game-based learning approach to improving students' inquiry-based learning performance in social studies courses, *Computers & Education*, **81**, pp. 13–25, 2015.

55. J. L. Plass, B. D. Homer and C. K. Kinzer, Foundations of game- based learning, *Educational Psychologist*, **50**(4), pp. 258–283, 2015.
56. P. Pando Cerra, H. Fernández Álvarez, B. Busto Parra and P. Iglesias Cordera, Effects of using game-based learning to improve the academic performance and motivation in engineering studies, *Journal of Educational Computing Research*, **60**(7), pp. 1663–1687, 2022.
57. D. Oyserman, S. C. O'Donnell, N. Sorensen and K. M. Wingert, Process matters: Teachers benefit their classrooms and students when they deliver an identity-based motivation intervention with fidelity, *Contemporary Educational Psychology*, **66**, 101993, 2021.
58. C. G. Anderson, J. Dalsen, V. Kumar, M. Berland and C. Steinkuehler, Failing up: How failure in a game environment promotes learning through discourse. *Thinking Skills and Creativity*, **30**, pp. 135–144, 2018.
59. J. W. Creswell and J. D. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*, 5th edn, Sage Publications, Thousand Oaks, California, 2017.
60. H. Y. Chang, T. J. Lin, M. N. Lee, S. W. Y. Lee, T. C. Lin, A. L. Tan and C. C. Tsai, A systematic review of trends and findings in research employing drawing assessment in science education. *Studies in Science Education*, **56**(1), pp. 77–110, 2020.
61. StataCorp. *Stata Statistical Software*, 14th edn, College Station, Texas, 2015.
62. QSR International Pty Ltd, *NVivo*, 2020.
63. N. Weber, D. Duncan, M. Dyehouse, J. Strobel and H. A. Diefes-Dux, The development of a systematic coding system for elementary students' drawings of engineers, *Journal of Pre-College Engineering Education Research*, **1**(1), pp. 49–62, 2011.
64. A. D. Newley, E. Kaya, E. Yesilyurt and H. Deniz, *Measuring Engineering Perceptions of Fifth-grade Minority Students with the Draw-an-Engineer Test (DAET)*, American Society for Engineering Education Annual Conference & Exposition, Columbus, Ohio, 2017.
65. M. Savin-Baden and C. H. Major, *Qualitative research: The essential guide to theory and practice*, Routledge, 2013.
66. M. B. Miles, A. M. Huberman and J. Saldaña, *Qualitative data analysis: A methods sourcebook*, 4th edn, Sage Publications, 2020.
67. B. M. Capbianco, E. Deemer and C. Lin, Analyzing predictors of children's formative engineering identity development, *International Journal of Engineering Education*, **33**(2), pp. 44–54, 2017.
68. S. Reissner-Roubicek, "The guys would like to have a lady:" The co-construction of gender and professional identity in interviews between employers and female engineering students, *Pragmatics*, pp. 231–254, 2022.
69. D. J. Wu, K. C. Thiem and N. Dasgupta, Female peer mentors early in college have lasting positive impacts on female engineering students that persist beyond graduation. *Nature Communications*, **13**, 6837, 2022.
70. D. Oyserman, *Pathways to Success Through Identity-Based Motivation*, Oxford University Press, Incorporated, 2015.
71. E. Horowitz, N. Sorensen, N. Yoder and D. Oyserman, Teachers can do it: Scalable identity-based motivation intervention in the classroom. *Contemporary Educational Psychology*, **54**, pp. 12–28, 2018.
72. National Science Foundation, https://www.nsf.gov/news/mmg/mmg_disp.jsp?med_id=80126, Accessed 26 August 2023.

Amanda Obery is an Assistant Professor of Elementary Math & Science Education at Central Washington University. She is fortunate to be able to pursue her research interests in STEM education through a number of lenses in the interest of serving the communities she inhabits. https://orcid.org/0000-0002-5202-4798

Nicholas Lux is an Associate Professor of Curriculum and Instruction in the Montana State University Department of Education and is an affiliate in the Montana Engineering Education Research Center (MEERC). He has worked in the field of educational technology contextualized in K-12 and higher education for almost 25 years. His teaching and research interests include technology integration in K-12 STEM teaching and learning, and in particular, engineering education and STEM identity formation. Nicholas Lux, https://orcid.org/0000-0002-7434-0660

Paul Gannon is a Professor of Chemical and Biological Engineering and Associate Director of the Montana Engineering Education Research Center at Montana State University. Paul Gannon, https://orcid.org/0000-0003-0888-8158