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STEM Identity Development: Examining the Effect of Informal Summer Learning Experience on Middle School Students

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introduction

Technological innovations, economic prosperity, and security depend on STEM literacy. Increasing STEM literacy can be achieved by teaching academic concepts through real-world applications and combining formal and informal learning in schools, after schools, the community, and the workplace [1]. Studies show that students who have an increased interest in science, mathematics, and engineering in the early years (elementary and middle schools) of their education are more likely to pursue a STEM-related career [2]. Informal STEM education experiences are considered critical to developing the future STEM workforce [3]. Informal STEM education can also help to address equity and access issues in STEM education. Students from underrepresented groups, including women and minorities, may face barriers to STEM education in traditional classroom settings, but informal STEM education can provide alternative avenues for learning and engagement that are more inclusive and accessible [4]. Informal STEM education often emphasizes hands-on and inquiry-based learning, which can be more engaging and effective for some students than traditional lecture-style teaching. Informal learning experiences can help individuals develop an interest in STEM that lasts beyond their formal education, leading to continued engagement with and contribution to STEM fields throughout their lives. Student STEM identity development is thought to relate to central aspects of their lives, including increased motivation, well-being, academic confidence, and career interest. Research has shown that a primary predictor of pursuing a STEM career is engaging in informal conversations and digital media that involve STEM topics [5]. Informal summer camps can facilitate STEM interest development [6] and fill in the gap of knowledge access during the summer [7,8]. Hands-on projects and workshops with industry experts [9] increase students' self-confidence, and site visits to authentic examples of engineering introduce students to the social sectors that leverage STEM knowledge [10], helping to develop self-confidence and STEM identity formation.

The purpose of this study is to examine the impact of a three-week STEM summer camp conducted on the university grounds by the engineering faculty and a undergraduate and graduate students mentors on middle school students of grades 6, 7 and 8. Participants were selected to represent a broad range of both demographics and genders. The camp is designed to promote STEM identity development by introducing students to engineering methods, scientific concepts and hands-on projects in hospitality and entertainment engineering in informal settings. Students connect these concepts to the entertainment and hospitality field trips and the face-to-face sessions with industry experts to learn applications before developing small-scale projects. This study examines the dynamic process of middle school student identity development over the camp periods in two years of the project. Data analysis for year 1 is presented and informed changes to the camp. Both year 1 and year 2 data collected is compared to understand the impact of the changes. The following research questions are explored in this paper in relation to informal STEM learning. The first question was designed to understand how elements of the Dynamic Systems Model of Role Identity (DSMRI) [11] changes over the course of the STEM lab in relation to context. The second question was designed to examine which specific camp activities were the most powerful drivers of identity change. The first and second questions are answered using only year 1 data. The third question was designed to assess improvements in content delivery from the first and second year of the camp.

RQ1: How do the DSMRI constructs change throughout the camp in relationship to camp activities? Are there theoretically interpretable changes in the strength of relationships over time?

RQ2: What camp activities are most impactful for the students when interpreting what tools and technology engineers use and how engineers use tools and technology?

RQ3: How does changing camp delivery mechanisms based on year 1 data affect students in year 2?

theoretical and implementation framework

The DSMRI is a theoretical framework that explains how an individual's roles and identities are interconnected and can influence their behavior and cognition. The DSMRI has been utilized to measure change in identity formation during informal learning experiences [12,13] The DSMRI consists of 5 components: emotions, ontological and epistemological beliefs, purpose and goals, self-perceptions and definitions, and perceived action possibilities that comprise role identity (e.g. trying on the role of an engineer). Kaplan et al. proposed an identity systems perspective on self-regulated learning [14]. They argued that an individual's identity system, which includes their beliefs, values, and self-conceptions, can influence their motivation and self-regulation. Moreover, they suggested that an individual's identity system is dynamic and can change over time, as they encounter new roles and experiences. Garner et al. researched the overlap between DSMRI and situated motivation in their study of undergraduate engineering students [15]. They found that the emergence of outreach ambassador role identities in students was associated with increased motivation and engagement in their engineering coursework. This suggests that an individual's sense of identity and the roles they occupy can impact their motivation and behavior, in line with the DSMRI. This dynamic view of identity emphasizes the ongoing process of identity development and the ways in which different roles and identities can interact and influence each other. DSMRI proposes that an individual's roles and identities are not fixed, but rather emerge and evolve over time as a result of complex interactions between internal and external factors. These internal factors include an individual's cognitive, affective, and behavioral processes, while external factors refer to the social, cultural, and historical contexts in which they are situated.

An informal learning educational approach integrates amusement and fun factors into learning [16-19] science, math, technology, and engineering design. A summer camp can be used to create meaningful learning activities with the potential to capture learners' interest free of the pressure and anxiety of external assessment [20] and create lasting, early learning effects. The learning experiences are designed in social, playful, and engaging ways to foster students' natural tendency to ask questions, explore, and experiment [21].

camp description

Middle school students attended a three week summer camp conducted on a university campus. Participants attended the camp daily 8 hours a day. The three weeks of the camp included field trips to the city sites, engineering and hospitality design labs on campus, and science learning (week 1), hands on active learning using interactive programming and verification, engineering design using microcontroller, LEDs, sensors, Wi-Fi, and motors (week 2), and project design, packaging and presentation to public (week 3). In the first week, participants visited sites and interacted with professionals in the entertainment and hospitality industry. Students learned about large-scale displays, bending laser rays and more from show creators. At the “hospitality” innovation center, participants were exposed to robots with uses in the hospitality industry, innovative structural materials for walls and bedding, room entertainment, 360-degree displays, and more. Another field trip introduced the technology of operating the height and the angle of water streams, creating a visual show. On campus field trips were taken to the college of hospitality golf center and entertainment engineering design lab. The above field trips were offered depending on site availability and scheduling; consequently, field trips differed from Year 1 to Year 2. In the second week, participants were introduced to science of light and color, electricity and magnetism, embedded systems design using microcontrollers, sensors (IMU, LED), motors, modelling with Tinkercad, and creating a 3D print. To familiarize students with embedded systems related to engineering and hospitality concepts, we introduced students to various technical skill sets. They explored motors, LEDs, small displays, sensors, microcontrollers, object-oriented C programming (Arduino), mobile robots, robotic arm, and drones furnished with a camera. For learning related science concepts, we alternated between basic science discussions on physics of light, color and electromagnetism tailored for participant age with exploration of learning kits such as SNAP circuits and magnetism learning kits as a team building activity, online crossword puzzles (integrated with the learning materials), and concept drawing competition among groups. For learning the basics of C++ programming, we used an online tool with a built-in compiler for instant self-test and feedback. Additionally, there was an introduction and exploration of Tinkercad, 3D and laser-cut printers to build and decorate their designs and display the team logos. Material learned in week 2 was used to propose and develop group projects. The third week was devoted to designing the final projects inspired by the site visits.

The participants were organized into teams of 4-5- students, and each team was mentored by an undergraduate engineering student. Participants were placed into teams during the first day of the camp. Undergraduate engineering mentors were selected based on academic performance, prior experience working with middle school-age kids and the statement of their commitment to the duties, and their career goals. Undergraduate and graduate engineering students who were selected for mentoring received about 30 hours of training on behavioral aspects, team management, and responsibilities related to the camp. They received technical training for hardware, software and project development related to the materials used in the camp. Mentors picked and coded projects to be used for their group during the training before the camp. Mentors used this time to familiarize themselves with troubleshooting and brainstorm on ways to help participants through the design process. During the summer camp, undergraduate mentors assisted with all learning and development activities and were expected to be role models for participants. Engineering professors and graduate assistants provided content information while also overseeing technology and project related problems. The educational psychology professor and one graduate assistant collected study data while also tracking student participation.

Camp structure was improved from year 1 to year 2 by providing more scaffolding opportunities for participant learning during week 2. Specifically, mentors not only made sure that participants conduct lab exercises, but also explain reasons of why certain things do not work and explain troubleshooting instructions. Mentors training was improved to expand upon their project exposure to ensure they were able to explain the project development plan and ensure that every student in the team and the team as a whole understood the goals and were able to participate in the project development.

data collection techniques and measures

Data collection consisted of three techniques: survey, reflection activity, and engineering identity formation assessment. Survey data were collected at 8 time points using established instruments that had produced evidence of reliability and validity in populations of middle school students. One instrument was developed from the established instruments' questions that related to each DSMRI component, discussed later in the paper. Participants also provided what was the best part of the day and the most challenging part of the day in open responses. The reflection activities were collected at 3 time points and were utilized to assess what camp activities were most related to how students perceived how engineers use technology and what tools engineers use, providing information about how the contextual aspects of the camp including what tools they were working with and what areas of engineering they were exploring were related to identity formation. During the reflection activity, participants were given a paper that was divided into two sides. On one side, participants were asked to draw or list tools and technology engineers use. On the other side, participants were asked to draw or list how engineers use tools and technology. The activity was adapted from another drawing activity related to understanding science [22]. We also conducted a shortened version of the survey at 3 time points referred to as the engineering identity formation assessment. The shortened survey consisted of asking four DSMRI constructs. Data collection schedule differed from Year 1 and Year 2 because of logistical issues out of the camp's control. Year 2 presented a new national holiday that did not allow us to hold the camp. The qualitative and quantitative data were mixed during the interpretation phase of the research, where we examined how changes in the survey responses aligned with camp activities and perceptions of the tools engineers use.

Survey measures were taken from several other instruments to measure the five aspects of the DSMRI: emotions, ontological and epistemological beliefs, purpose and goals, self-perceptions and definitions, and perceived action possibilities. All five aspects of the DSMRI were used in the survey activity. Only purpose and goals and perceived action possibilities questions were used for the engineering identity formation assessment.

Emotions were operationalized as four components: affective, cognitive, motivational, and physiological. Two underlying factors were used to measure emotions: enjoyment (4 items; α= .86; ω= .87) and hopelessness (4 items; α=.80 ; ω=.84). All reported alpha and omega values are averaged values from each time the items were used during year 1. The items were adapted from the AEQ-S scale [23]. All emotion questions were listed in one block with the following prompt "Please consider how you felt today in the camp". Enjoyment was defined as having feelings of joy while learning content during the summer camp. An example of enjoyment is "I enjoyed the challenge of camp activities". Hopelessness was defined as the opposite emotional counterpart of enjoyment: feeling discouraged while learning new content. An example of hopelessness is "I felt helpless today".

Ontological and epistemological beliefs were operationalized as student's worldview and how they perceive knowledge is created and changed. Two underlying factors were used to measure ontological and epistemological beliefs': ingenuity (4 items; $\alpha = .84$; $\omega = .89$) and solution seeking (4 items; $\alpha = .73$; $\omega = .82$). The items were adapted from the Inventive Mindset Scale [24]. All ontological and epistemological beliefs questions were listed in one block with the following prompt "Please consider how you saw yourself today in the camp". Ingenuity was defined as creative thinking, imagination, and idea generation. An example of ingenuity is "I had lots of good ideas today". Solution seeking was defined as problem solving, openness to novelty, and persistence. An example of solution seeking is "I solved problems today".

Purpose and goals were operationalized as how a student perceives their place in relation to learning. Two underlying factors were used to measure purpose and goals: Perceived Instrumentality (3 items; $\alpha = .84$; $\omega = .86$) and Interest (3 items; $\alpha = .92$; $\omega = .92$). The items were adapted from previously used items for engineering students [25]. All purpose and goals questions were listed in one block with the following prompt "Please consider how useful the activities were today in the camp". Perceived instrumentality was defined as how useful students find content in terms of their future in general, school, and other general classes. An example of perceived instrumentality is "What I learned in today will be important for my future goals". Interest was defined as interest in the subject material. An example of Interest is "I found fulfillment in doing engineering ".

Self-perceptions and definitions were operationalized as students' personal and social attributes while learning. Two underlying factors were used to measure self-perception and definitions: Self-efficacy (3 items; $\alpha = .83$; $\omega = .86$) and Self-concept (3 items; $\alpha = .73$; $\omega = .78$) [26-28]. All self-perceptions and definitions questions were listed in one block with the following prompt "Please consider how confident you were today in the camp". Self-efficacy was defined as students' self-assessment in solving content related problems. An example of Self-efficacy is "I handled whatever challenges came my way". Self-concept was defined as how a student perceives their own ability to learn the camp concepts. An example of self-concept is "I learned camp concepts quickly".

Perceived action possibilities were operationalized as knowledge and perceptions of behavior (i.e. cognition, cognitive and behavioral strategies) [11] Two underlying factors were used to measure perceived action possibilities: possible selves (4 items; $\alpha = .77$; $\omega = .85$) and self-regulation (3 items; $\alpha = .80$; $\omega = .82$) [29, 30]. All perceived action possibilities questions were listed in one block with the following prompt "Please consider how much you wanted to become an engineer today". Possible selves is an extent students could see themselves as engineers now and in the future. An example of possible selves is "I felt confident I could become an engineer today". Self-regulation was defined as the frequency in which students consider engineering outside of the camp. An example of self-regulation is "I will use the internet to learn more about camp ideas in my free time".

results

Mean values from each day were placed in a longitudinal plot and correlations between constructs were explored to answer research question 1. Table 1 presents mean, standard deviation, alpha and omega values for each construct measured during survey data collections. We present only data collected for week 1 day 1 for the sake of space.

Table 1: Descriptive statistics for all study variables for year 1 week 1 day 1 (35 participants)

Scale	Measure			
	M	SD	α	ω
Joy	4.18	0.63	0.75	0.81
Ingenuity	3.99	0.81	0.77	0.80
Hopelessness	2.03	0.73	0.66	0.72
Solution seeking	4.03	0.59	0.57	0.69
Perceived intstrumentality	3.99	0.83	0.76	0.79
Engineering Interest	4.01	1.00	0.88	0.89
Self-efficacy	4.02	0.62	0.67	0.73
Self-concept	3.72	0.79	0.75	0.76
Possible selves	3.89	0.89	0.84	0.89
Self-regulation	3.64	0.87	0.73	0.78

Table 2 presents mean, standard deviation, alpha and omega value for each construct measured during the shortened survey data collections for examining engineering identity formation.

Table 2: Descriptive statistics for all study variables for year 1 week 1 day 3 (33 participants)

Scale	Measure			
	M	SD	α	ω
Perceived instrumentality	3.79	0.82	0.79	0.80
Enginering Interest	4.02	0.93	0.92	0.92
Possible selves	3.96	0.81	0.80	0.90
Self-regulation	3.27	0.93	0.78	0.80

Visual inspection of constructs' skew and kurtosis show normal distribution. Alpha and omega values were relatively high for each construct and day. If we compare Tables 1 and 2, the engineering identity formation activity appeared to produce higher reliability within constructs, except for possible selves.

Figure 1 on the following page shows the longitudinal means scores plot made to understand how the DSMRI constructs changed throughout the camp. The plot was created to better understand how the constructs change over time, related to research question 1.

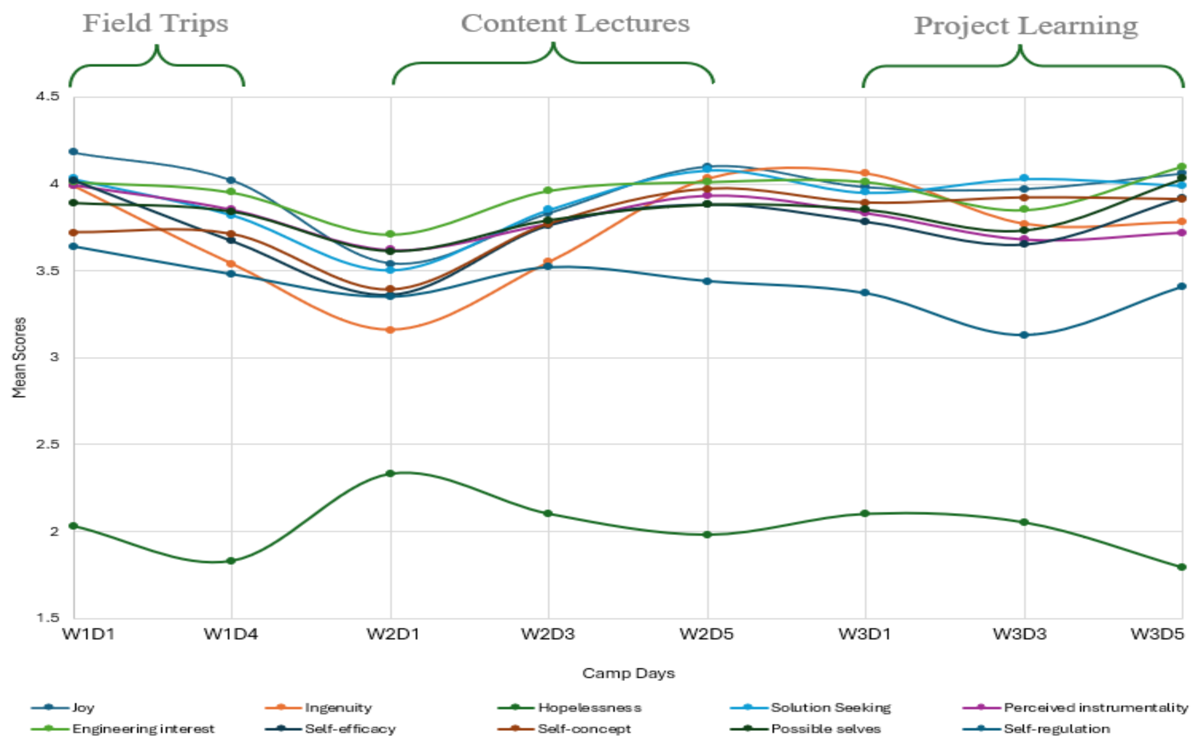

Figure 1: DSMRI Year 1 Mean Scores

Note. Each data point represents a camp day, and each line represents a separate DSMRI construct. The brackets found above the figure indicate what camp phase is occurring during each day.

In Week 2, Day 1, hopelessness increases in the participants while all other constructs decrease. In Week 3, Day 3, self-regulation measure decreases which happens in combination with other DSMRI constructs shifting up and down. Most notable is ingenuity decreases along with the increased demand for students to self-regulate in the project-based learning phase. By the end of the camp, students on average were reporting lower levels of self-regulation than any other DSMRI construct (with the exception of hopelessness which was a negative construct). Table 3 on the following page reports the strength of relationships between the engineering identity formation variables over the three-week time period.

Table 3: Correlation matrices for shortened survey (engineering interest activity) data collections during Year 1

Scale	Perceived instrumentality	Engineering interest	Possible selves	
Engineering interest	0.685 (<.001)	-	-	Week 1 Day 3
Possible selves	0.467 (.006)	0.597 (<.001)	-	
Self-regulation	0.550 (<.001)	0.557 (<.001)	0.685 (<.001)	
Scale	Perceived instrumentality	Engineering interest	Possible selves	
Engineering interest	0.846 (<.001)	-	-	Week 2 Day 4
Possible selves	0.545 (<.002)	0.740 (<.001)	-	
Self-regulation	0.721 (<.001)	0.845 (<.001)	0.731 (<.001)	
Scale	Perceived instrumentality	Engineering interest	Possible selves	
Engineering interest	0.818 (<.001)	-	-	Week 3 Day 4
Possible selves	0.318 (.087)	0.452 (.012)	-	
Self-regulation	0.627 (<.001)	0.566 (<.001)	0.554 (.002)	

The strength of the relationship between perceived instrumentality and engineering interest increased between the end of week 1 and the end of week 2, as the strength of the relationship between engineering interest and self-regulation increased over the same time period. Furthermore, the relationship between perceived instrumentality and future possible selves became non-significant in week 3.

A content analysis was conducted on the reflection activities data to answer research question 2. The content analysis for the reflection activities revealed what students saw as the most impactful activities for understanding what tools/technology engineers use and how engineers use tools/technology. The code that appeared the most in Week 1 was Tcad (Tinkercad) used by participants to develop 3D models. The code that appeared the most in Week 2 was the LEDlab - a camp activity where students programmed the microcontroller to light up a single Light Emitting Diode (LED) and an LED array. The code that appeared the most in Week 3 was Project and represented the final projects students build during the entire third week of the camp. All three activities had high levels of hands-on learning and the possibility for students to connect the task with the learned concepts, i.e. if the LED did not light up then the code had to be changed to turn on LEDs.

Independent t-test comparisons were conducted to explore research question 3. Table 4 presents the significant t-test values for each time point for year 1 and year 2. A significant t-test value means there is a significant difference between the mean value of year 1 and year 2 cohort.

Table 4: Significant t-test for survey comparing year 1 and year 2 cohort

Time point	Year 1 day	Year 2 day	Significant difference
2	W1D4	W1D3	Self-efficacy (-2.553,0.013) Self-concept (-3.322,0.002) Self-regulation (-2.649, 0.01)
3	W2D1	W1D5	Joy (-2.630, 0.011) Ingenuity (-5.004, <.001) Solution seeking (-3.118, 0.003)

Time point	Year 1 day	Year 2 day	Significant difference
			Engineering interest (-2.333, .023) Self-efficacy (-4.568, <.001) Self-concept (-3.651, <.001) Self-regulation (-2.357, 0.022)
5	W2D5	W2D3	Hopelessness (2.511, 0.015) Solution seeking (-2.29, 0.026) Perceived instrumentality (-2.565, 0.013) Self-efficacy (-2.012, 0.049) Self-concept (-2.121, 0.038) Self-regulation (-2.988, 0.004)
6	W3D1	W2D5	Hopelessness (2.612, 0.012)
7	W3D3	W3D3	Ingenuity (-2.148, 0.036) Self-efficacy (-2.464, 0.17) Self-regulation (-3.776, <.001)
8	W3D5	W3D5	Self-regulation (-2.806, 0.007)

Results for comparing time points 1 and 4 in the above table are omitted because there was no significant difference found using an independent sample t-test comparing the two cohorts. The t-statistic followed by the p-value is presented after each scale name. A negative t-statistic suggests that year 1 has a mean value less than year 2, while a positive t-statistic suggests that year 1has a greater mean value than that for year 2.

Table 5 presents the significant t-test values for identity formation survey between the year 1 and year 2 cohort. All significant scales show a negative value, suggesting that year 1 mean values are less than those of year 2.

Table 5: Significant t-test for identity formation survey comparing year 1 and year 2 cohort

Time point	Year 1 day	Year 2 day	Significant difference
1	W1D3	W1D4	Self-regulation (-2.802, 0.042)
2	W2D4	W2D4	Perceived instrumentality (-2.688, 0.01) Engineering interest (-2.517, 0.015) Self-regulation (-2.797, 0.007)
3	W3D4	W3D4	Perceived instrumentality (-2.706, 0.009) Self-regulation (-2.690, 0.009)

Some of the reported differences in Table 4 may be due to the camp topic influencing the differences. For example, year 1 week 2 day 1 participants were learning about Arduino and on year 2 week 1 day 5 participants were learning about programming a simple robot car to follow a line. Both days are measured at time point 3 during each respective year. Table 6 presents t-test values for camp activity days that did not coincide with the same time point for both years.

Table 6: Significant t-test for full survey comparing year 1 and year 2 cohort with same activities

Camp day	Year 1 time point	Year 2 time point	Significant difference
W2D1	3	4	Joy (-2.135, 0.037) Ingenuity (-3.392, 0.001) Solution seeking (-2.699, 0.009) Perceived instrumentality (-2.354, 0.022) Self-efficacy (-3.116, 0.003) Self-concept (-2.774, 0.007) Self-regulation (-2.124, 0.038)
W2D3	4	5	Joy (-2.526, 0.014) Ingenuity (-3.596, <.001) Hopelessness (3.089, 0.003) Solution seeking (-3.544, <.001) Perceived instrumentality (-3.354, 0.001) Engineering interest (-2.171, 0.034) Self-efficacy (-2.6, 0.012) Self-concept (-2.905, 0.005) Self-regulation (-2.928, 0.005)
W2D5	5	6	Hopelessness (2.093, 0.041)

discussion

The results of the current study support many aspects of the DSMRI framework. During the first day of the second week, students encountered a lecture of digital systems, computers and algorithms and an introduction to Arduino platform. Although both sessions were based on interactive learning, that was the longest lecture-based activity after the week of field trips, and it also was characterized by a fast pace of a complex material. On this day, the feeling of hopelessness increased while other positive activating perceptions decreased. The DSMRI postulates that many aspects of identity development are influenced by students' emotional response to learning activities. Students who experience frustration are likely to interpret the physiological and psychological markers of frustration as an indication that the activity they are participating in is not for them, leading to decreases in self-concept and future goals.

Our content analysis of student perceptions of the tools/technology engineers use revealed that most students mentioned installing Arduino software as the most challenging part for week two day one. During this part of the camp, students were asked to download Arduino software to their laptops and engage in other-multi-step tasks such as installing the development board code libraries. Many aspects of this task were frustrating, including slow internet speeds, lack of compatibility with different operating systems, and other typical engineering challenges related to this type of routine. Students' negative emotional responses to these challenges appeared to lead to a phase transition in their identity system, as evidenced by large scale shifts in all measured components of the DSMRI, seen in figure 1. However, in Year 2, camp organizers made several changes to the Arduino activity. The organizers provided more training to mentors regarding troubleshooting and experience with Arduino projects and coding. The Arduino software was also installed locally for many participants. The changes led to less hopelessness for the Year 2 cohort on W2D3 and W2D5 and more joy on W2 D1 (as seen in Table 6).

The data indicated that students' identity systems rebounded by the end of the second week of camp, as evidenced by hopelessness decreasing and all other DSMRI constructs increasing by the end of week 2. Notably, feelings of ingenuity increased the most, along with feelings of joy and solution seeking. During this time period in the camp, the participants acknowledged active learning experiences as the most impactful experiences in the camp when defining the tools and technology engineers use and how engineers use the technology. When comparing, for example, the LED lab to the initial Arduino experience, there are perhaps two glaring differences worth describing: 1) the lab had straightforward directions and there was a clear pay off which allowed the students to light an LED with the code and 2) the lab connected directly with several real life examples participants encountered during field trips where the students observed LED displays. Students were able to play the role of an engineer by applying their prior knowledge and skills to a manageable hands-on activity. The results from this time period provide evidences for how motivation activates different DSMRI identity formation patterns (e.g. from emotions to purpose/goals) over time, particularly with regard to the role of context in shaping the role, direction, and strength of relationships within the identity system. When students are meaningfully engaged in solution seeking tasks, they experience those tasks as being something related to their sense of self, influencing the future goals they set for themselves, and their interest in becoming an engineer. These results not only provide the evidence for the dynamic role of motivation in shaping identity formation, but also for the complexity of the identity system [31] and, more broadly, for the use of complex systems research approaches that can capture stability and change in psychological systems [32].

It is also important to note that although the students' identity systems become more connected during the later stages of the camp, students' self-regulation, or their perceptions about their ability to control their own learning through the use of learning strategies and application of knowledge, continued to decrease during the third week. However, these decreases happened in conjunction with relatively high levels of positive activating components of the identity system including self-efficacy, self-concept, and solution seeking. Also, the correlations between engineering interest to self-regulation and perceived instrumentality to self-regulation both increased between week 1 and week 2, suggesting that students who maintained interest in camp activities were more likely to feel in control of their learning. Note that during this period of the camp students were working closely with undergraduate mentors on relatively complicated project-based learning tasks. Although more research is needed to explore this phenomenon, it is likely that combinations of, for example, high self-efficacy and moderate self-regulation are indicative of students tackling challenges that are just above their skill level under the tutelage of a mentor. It is also the case that the relationship between perceived instrumentality to future possible selves became non-significant in week 3 perhaps indicating that a contextually specific interest in engineering, as opposed to a utility-based perception of group projects (such as how the elements of the project might be beneficial to success in school), was driving the development of future goals for STEM. Future research can determine if psychological profiles that reflect these combinations of factors are related to improved identity formation and future interest in STEM disciplines.

Based on year 1 data gathered from students, several changes to camp curriculum were made: A stronger introduction to Arduino during week 2 by instructors and better scaffolding was provided from undergraduate mentors, the project based learning in week 3 was shifted to a more structured environment where participants were given defined roles that were agreed upon through their undergraduate mentors. Also, undergraduate mentors were motivated and worked closely with their teams. Looking at results from research question 3 (Tables 4, 5 and 6), all significant differences suggest the changes in content delivery provided participants in year 2 a better camp experience. For example, when comparing week 3 day 3 between the two cohorts, camp participants in year 2 on average exhibited more ingenuity, self-efficacy, and self-regulation. Table 6 represents significant differences during the Arduino learning experiences in the camp. A significant positive t-statistic for week 2 day 3 and week 2 day 5 for hopelessness suggests camp participants in year 2 exhibited less hopelessness on average than year 1. The findings indicate scaffolding in project based learning and active learning allows camp participants to have a more positive experience. We suggest other middle school camps think critically about how much autonomy and troubleshooting responsibility is provided to their participants. Participants should be given the opportunity to attempt a solution on their own but should be given strong guidance so a positive learning experience may occur.

conclusion

In this work, we studied the STEM identity formation in a sample of 35 middle school students for year 1 and a sample of 32 middle school students for year 2 of grades 6,7 and 8 during a three-week summer camp in two years, respectively, which was held on the university campus. Longitudinal mixed methods research design and alignment of quantitative surveys and qualitative reflection activities timed with the camp activities were utilized by the authors. DSMRI components were used as a theoretical framework to study the impact of context on student identity formation. The analysis revealed factors of increasing feelings of hopelessness among campers and decreased feelings of ingenuity, and those which activated feelings of joy and future interest in engineering. Active learning experiences, evidence based learning and hands-on activities and connections of projects to the field trips to entertainment and hospitality sites facilitated students' self-perception as engineers. It was found that STEM identity development for middle school students can be negatively affected by the learning environment activity, such as unavailability of resources (internet bandwidth while downloading the required code libraries) or intellectual challenges (too much content in a short amount of time can lead to negative emotions). The perceived negative experience may develop into feelings that the activity they are participating in is not for them, leading to decreases in self-concept. Improving the learning environment through scaffolding learning and decreasing the length of time to accomplish a task (downloading a software and assisting with troubleshooting) helped improv the camp experience for the Year 2 cohort when compared to the Year 1 cohort. The paper contributes to engineering summer camp literature by showing participants identity development is contextual to several affective components, and manipulating the learning environment can lead to positive improvements in participants' personal experiences. The positive experience may then lead to participants choosing to pursue a STEM career in the future.

acknowledgement

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