Research in Engineering Education Symposium-2024
Jan 4-6, 2024 - Hubballi, India

Exploring the role of engineering skills-building activities amongst youth in rural Karnataka

Heather R. Beem; David Asante-Asare, and Pashington Obeng
Ashesi University, Ghana
Corresponding Author Email: hbeem@ashesi.edu.gh

Abstract

Context

Engineering skills-building activities, such as those found within the Creative Capacity Building (CCB) approach, have been used as a human capital-building approach to enabling developmental progress amongst rural communities.

Purpose or Goal

The Siddi (Afro-Indian) community can tend to view themselves as outsiders within broader Indian society. This study began delving into two research questions: 1) What constructs may be apt for describing Siddi youths' experience? 2) To what extent do self-perceptions change as Siddi youth engage in an engineering skills-building session?

Methods

This mixed-method exploratory study began with stakeholder interviews in a village and nearby town within Karnataka State. Coding was done to ascertain which constructs resonated well. A three-day CCB-inspired training was then deployed for three different groups of youth – a private-school in the town, a public-school in the town and hostel students in the village. Pre-post changes in Likert scale responses on a survey were analyzed using t-tests and Hedge's g tests to ascertain how interest in STEM, creativity and confidence levels were affected.

Outcomes

Interest emerged as a common first step in the Siddi youths' narrative. As a result of the training, interest in engineering increased with statistical significance and large effect size for all disaggregations. The public-school students performed objectively better than the private-school students during the training, however they reported lesser gains in self-perception.

Conclusion

Engineering skills-building can have a significant impact on rural youth, such as those from the Siddi community. Stereotype threat may however limit its manifestation in their self-perceptions.

Keywords—creative capacity building, design-build activities, Siddi community

I. INTRODUCTION

A. Background on the Siddi Community

Some rural villages in Karnataka State are the home of members of the Siddi (African-descent) community. As the authors support teaching and learning in an African high education institution, we sought to understand how engineering skills development, akin to what we currently offer in Africa, might impact members of this community in India, South Asia.

The Siddi people are descendants of Africans who have been in India for over 800 years as a result of enslavement and travels by merchants and artisans. They constitute a minority group, with a population of about 5,000 in Karnataka within a country of 1.4 billion. They live in clusters in parts of North Karnataka. They tend to only travel to the bigger towns and cities on market days and other times when they need to purchase items outside of their immediate communities. Otherwise, they live lives that are largely geographically and socially isolated from the broader society. Even amongst the surrounding villages where they live, they tend to be amongst the most marginalized communities. For example, even if Siddis live or settle next to Gowlis (shepherds), Lambanis (those originally responsible for providing firewood and construction), by virtue of pigmentation or skin color, the Siddis stand out even in those clustered communities where the others are also marginalized. The Siddis have been reclassified as a Scheduled Tribe by the Central Government of India. They are thus entitled to subsidized education, rationing of food items, and health care, although not all of them are still able to access these.

Based on the authors' previous interviews of Siddi community members, they tend to see themselves as outsiders whose forebears originated outside of South Asia. They tend to be self-conscious outsiders that point to how they have less resources than others. For example, Siddis who attend school outside of their immediate communities can exhibit a sense of shyness, withdrawal, and initial inability to advance as expected by the educational standards. In such a context where the school may be headed by Indians of larger society and different complexion, Siddi students may tend to cluster together. By so doing, they may either consciously or unconsciously reinforce their perceived differences – how they think of themselves in relation to how the larger society sees them. Their self-consciousness may sometimes inadvertently be reinforced by others they interact with in society. For example, staff and teachers in a school may unknowingly pass comments that Siddi children are not as capable as the others, which can in turn feed the misperception that they cannot perform at the same

https://doi.org/10.52202/073963-0026

level as others. Any intervention that manages to break down any perception of low self-esteem or self-consciousness as outsiders could hold value.

The aim of this study was to begin exploring the role of design-build activities on internal attitudes and external livelihood factors amongst the members of a community of African descent located in rural India. We hypothesize that training in design methodology and use of basic tools will empower the youth so that they can advance themselves in and out of school. By so doing, they in turn can inspire others since they can be role models for those who may not necessarily benefit directly from the intervention.

B. Stereotype Threat

Stereotype threat (Steele, 1997) is an effect studied in US education research and which originally focused mainly on the context of African American performance in school. It is the case where minority groups conform to the negative stereotypes they are viewed as, even on something like standardized exams. It is possible that this effect may have a strong influence here as well. For example, students from the majority group and attending a wealthier private-school likely receive messaging that they are better off than others. In that case, any positive input they receive may easily boost their self-perception. And the opposite can be true for those in the minority. One can either internalize stereotypes or reject them. But in either case, breaking the minority groups away from stereotypes likely requires a concerted effort.

C. Engineering Skills-Building

Designed and pioneered by MIT D-Lab, Creativity Capacity Building (CCB) is a workshop in which participants from a community co-create low-cost solutions using local resources. They learn the design process, basic fabrication skills and teamwork (MIT D-Lab, 2023). Since 2007, it has been deployed in dozens of countries spanning Africa (Taha, 2011), Southeast Asia (Drain, Shekar & Grigg, 2019) and beyond. The users have equally spanned a diverse set, such as refugees, mining community members, and farmers. Although quantifying the exact impact of CCB can seem elusive (McWilliam, Dawson, & Tan, 2008), many stories of its impact exist (Childs, 2017), and participants typically report an increase in confidence to solve challenges using local resources and feeling inspired to share the process with others (MIT D-Lab, 2023).

A shorter version of the full CCB training was offered in this intervention. Key elements of the 5 full-day program were offered within three 1.5-3 hour long sessions. This included one design challenge, fabrication skills practice, and one group design-build project.

In a similar vein, engineering skills-building has been deployed through a project-based learning approach in courses at Ashesi University in Ghana. First semester students were seen to significantly increase in self-efficacy after they engaged in all the elements described above, but over the course of one semester (Beem, 2021b). Evidence from these two approaches suggests the possibility of Siddi youth changing their self-perceptions as they engage in design-build activities.

D. Author Positionality

Author 1 is an engineering faculty at Ashesi University, where she has designed and led multiple design/project-based courses. She has also facilitated hands-on training sessions for pre-tertiary STEM teachers in multiple African countries. She is an American who has been living in Ghana for the last seven years. The trip described in this study constituted her first time spent in India.

Author 2 is a Ghanaian and a recent alumni of Ashesi University's engineering program. He served as the Teaching Assistant for Author 1's Introduction to Engineering course, in which he facilitated hands-on experiences for the students throughout the semester.

Author 3 is a Ghanaian who has been a humanities faculty in both US and Ghanaian institutions. For more than 20 years, he has supported various efforts in the rural community in this study. He has engaged closely with a group of nuns and priests whose organization has been based in the community for a similar amount of time.

Author 3 invited Author 1 to join him on one of his scheduled trips to this community and begin exploring if and how her work in Ghana could be extended to support this community. Authors 1 and 3 conducted a field visit to the community over a two-week period: July 17-31, 2019. This trip was aimed at building understanding of the context and gathering preliminary evidence on the hypothesis.

E. Research Questions

Given that this was Author 1's first trip to India, this work is intended to be exploratory in nature. The results were expected to enable the authors to identify any striking areas to focus their attention and thereafter design a narrower set of research questions in a follow-on study. For this exploratory study, two research questions (RQ) were used:

RQ 1: What constructs may be apt for describing Siddi youths' experience, vis-a-vis their position in society and future prospects?

RQ 2: To what extent do self-perceptions change as Siddi youth engage in an engineering skills-building session?

We hypothesize that aspirations and confidence will capture Siddi youths' experience, and we hypothesize that their interest in STEM, creativity and confidence will increase from the intervention.

II. METHODOLOGY

This work took the form of a mixed-methods exploratory study. A needs assessment was first conducted and then the training intervention was delivered. Surveys and interviews were conducted in English for a few parties (private-school

Proceedings of REES 2024 KLE Technological University, Hubballi, India, Copyright © Heather R. Beem, David Asante-Asare, Pashington Obeng, Exploring the role of engineering skills-building activities amongst youth in rural Karnataka

students and some adults) and the rest were conducted in Kannada. Nearby parties served as translators for the researchers.

A. Method 1 – Needs Assessment

The first few days were spent getting to know some of the many stakeholders in the diverse communities of study. This included Siddis (Indians of African descent), other Indians (Gowlis etc.), nuns, priests, convent staff, and more.

As part of the needs assessment, interviews and design challenges were carried out with a few of the stakeholder groups. This included the four (4) full-time staff at the local convent, five (5) Siddi male youth residing in the village, twenty one (21) of the girls (class 8-10) who reside in the village hostel at the convent, fifteen (15) students in the 7th grade class at the public school in the nearby town who also reside in the village hostel, and then twenty-one (21) students in the 9th grade class at the private school in the nearby town. Each of these groups were engaged separately. English was used for the interviews with the convent staff and the private school students, and Kannada was used with the other groups. A translator supported with real-time translation to English.

A "banana raise" design challenge served as an icebreaker and fun activity for each group to engage in, as they challenged themselves to stack bananas on two sheets of paper. Through a combination of group interviews and paper surveys, questions about their background, parents' work, and career aspirations were asked.

B. Method 2 – Training

For the three groups that went on to receive the training (the girls in the village hostel, the private-school students in the nearby town, and the public-school students in the nearby town), they also completed a written pre-survey. They were asked to rank, on a scale of 1 to 10 (where 10 is the highest), their interest in science, interest in engineering, how creative they think they are, and how confident they are to design and build their own product.

These groups were also asked to complete a 3-question creativity exercise. Based on the key components that researchers have tended to decompose creativity into, a creativity exercise (Beem & Jones, 2016) was administered here. Each question measures one of each of these components: fluency, which is the ability to generate quantities of ideas, flexibility, which is the ability to create different categories of ideas and to perceive an idea from different points of view, and elaboration, which is the ability to expand on an idea by embellishing it with details. Question 1 (fluency) asked participants to write down as many blue items they could possibly think of. The score was based purely on quantity – the higher the number of ideas, the higher their fluency. Question 2 (flexibility) asked participants to list as many unique use cases of a paper clip as possible. The score was based on the number of distinct responses given. Question 3 (elaboration) asked participants to write down their initials in the middle of a sheet of paper and then create as detailed of a drawing which included those initials as possible. The more details present in the drawing, the higher the mark. One minute was given for questions 1 and 2, and five minutes was given for question 3.

After finalizing logistical details, including scheduling and materials procurement, a 3-day training was administered to each of the three groups. One and a half hours were spent with the private-school students in the mornings, then three hours were spent with the public-school students in the evenings. After completion with these two groups, the same training was administered to the village hostel students for 3 hours each evening. An American university student served as a volunteer assistant throughout this intervention.

The training first led participants through skills building in electronics (learning to build a simple circuit), metalworking (cutting, filing, and snipping), and woodworking (cutting, hammering, filing, and drilling). The participants were placed in the same groups throughout. The participants were then guided to build a wooden box correctly sized to hold their circuit. Finally, participants were guided through a brainstorming activity, then tasked to draw at least one design per person of a lamp for their box, and then finally brought together in their group to finalize on a single design, plan for materials procurement (of which they were limited to whatever they could readily find around) and fabrication. Fig. 1 shows some examples of these training elements. The training can therefore be described as a prescribed set of skills-building tasks followed by an open-ended design prompt. Due to an immediate observation of students self-segregating by gender (with a physical distance between themselves), the author decided to mix the student groups across all classifications available in that particular group (gender and race).

Fig. 1. Training activities included (left) practicing fabrication techniques and (right) designing and assembling an LED-powered lamp

Each group had its distinct characteristics. The private-school in the nearby town was a new school, which had just recently opened, and it was the only English-medium school in a large radius. This school boasted of nice facilities, which came with higher school fees and an expectation of better educational

https://doi.org/10.52202/073963-0026

returns. No Siddi students were present in the class we engaged with here. In fact, less than 5 Siddi students were noticed during the authors' observation of the school during the period in question. Our training took place in their Physics Lab. Although this group was not the target group of interest, they served as a useful comparison. This training was provided to the Grade 9 students, who were 21 in number.

The public-school in the nearby town is located in close proximity to the private-school. The old school was founded in the 1990's, with the explicit goal of serving the marginalized communities in the area, including the Siddis. Some of the students live in the hostels on campus, and a group of 15 of the Grade 7 hostel students were selected by the staff for participation in the training. Their selection was based on their availability during the time period and aimed to include a mix of gender and race. The group make-up was 6 females, 9 males, 6 Siddis, and 9 Non-Siddis. Our training took place in an empty room in what appeared to be a temporarily abandoned Kindergarten building.

The final group of participants was the entire set of female students at the rural village hostel, spanning Grades 8-10. These were all females and they included 7 Siddis and 4 Non-Siddis. The economic background of these students is similar to that of the public-school students. Our training took place in an empty room in the convent building.

Upon completion of the training, the participants were asked to again rank their responses to the four questions asked at the beginning of the intervention. Pre-post differences were calculated across all questions and disaggregated across gender and race.

1) General Observations

General observations were noted by the lead author while the training took place and captured in journal entries. Select observations, such as those that repeated across multiple groups and/or were particularly striking, are mentioned in the Results.

2) Surveys

The pre-survey captured aspirations through an open-ended question "What kind of work do you hope to do as an adult?". Likert scale responses (1 to 10) were captured on their interest in science, interest in engineering, perceived confidence and perceived creativity levels. It also captured creativity levels, through the 3-measure creativity metric. On the post-survey, the same Likert scale questions were asked. An additional open-ended question "How do you feel after this program?" was added.

The open-ended responses were coded and then noteworthy and/or frequently-occurring codes were identified. Pre-post survey differences were calculated to determine any impact that the intervention had. Paired, two-tailed t-tests were used to determine statistical significance ($p < 0.05$). Hedge's g tests were used to measure the effect size of any statistically significant changes. The effect size was considered large if $|g| \geq 0.8$, medium if $|g| \geq 0.5$, and small if $|g| \geq 0.2$. All results were compiled in aggregate and also disaggregated across the training groups, gender, and race.

3) Focus Groups

The rural village hostel girls were not given the post-survey, but they were rather engaged through a focus group in an attempt to go deeper with the responses.

III. RESULTS

A. Method 1

1) Aspirations

The aspirations of the various stakeholders interviewed fit more or less into the categories one may expect globally. Many of those in the private-school aim to become doctors and engineers, whereas those in the public-school and village setting aim to become teachers and Catholic sisters. Hence they largely aim to be what they see. A few exceptions were seen. Some of the youth aspired towards professions beyond what their caste may seem to dictate. The Gowli females interviewed, for example, didn't cite wanting to become cowherders as their caste would prescribe. They rather aspired to become teachers, singers, and even a nurse.

The four convent staff members shared their original career aspirations, and all of them had, for one challenging reason or another, had to change course along the way. Where they had originally aspired to be a teacher or a software engineer, they had to shift and take up their current position. They displayed some sadness associated with that, but the fact that each of them has been living and working in the rural village for 7-20 years suggests that they have found new interest and fulfillment in this line of work. Also, they had clearly learned to work well together, as evidenced by their success in the design challenge. The ideas they came out with were unique compared to all other designs produced by other groups, and their teamwork was similarly strong.

All of this suggests that relying on career aspirations as a construct for describing how the Siddis view their place in society, may not be sufficient.

2) Confidence

In the course of data collection efforts, we asked four different translators to help translate "confidence". All struggled to do so – often using the English word itself and then filling in with examples in Kannada for how the translator interpreted it. This included, in one case, "competence to pass your exams".

Interaction with the male Siddi youth (in their 20's) of the

https://doi.org/10.52202/073963-0026

rural village brought out some other interesting aspects of Siddi life and perceptions here. The interviewees have currently found work as mechanics, welders, and cooks. They travel to the bigger cities to access more steady streams of income, despite the societal challenges they face as a result.

An attempt to determine how they view "confidence" led us to ask them how they would describe a farmer who persists in the face of adversity and continues working even when he faces a low-yield harvest. In responding, the participants kept bringing the conversation to interest – they would persist and go for something if they were interested in it. It then came out that half of them have created the first Afro-Indian rap group, and they are pursuing means of spreading their music. Interest and/or passion may be a necessary ingredient to help Siddis break free from negative perceptions.

B. Method 2

1) General Observations

The most immediate and obvious observation made when interacting with the students was that they self-segregated, especially along gender lines. They sat closely with those similar to themselves, chatting frequently and huddling together, but leaving a physical space between the girls and boys. The private-school students struggled to mix together even after multiple sessions. The public-school students, however, eventually mixed after prompting by the facilitators. And on the last day, during the design-build portion of the training, the public-school students began working together in their groups of mixed gender without any prompting.

The public-school students objectively performed better in the training than the private-school students– they worked more efficiently in their groups, they made it through the content more quickly, they broke less equipment. Secondly, the private-school students progressed too slowly to carry out the final session of the training – the one on design itself. Despite their prior experience working with electronics, the private-school students struggled to put their circuits together during the skills-building session. They got frustrated more easily and spent less effort troubleshooting than the public-school students.

The rural village girls' group was the easiest to work with, working well in their teams, keeping things in order, listening to instructions readily, and displaying strong motivation to complete the work. It is possible that as a single-gender group, it was easier for them to progress in their teams. Or perhaps simply being a smaller group made it easier. Or perhaps the fact that they are a small community living together and carrying out frequent programming together, made the teamwork easier as well.

Open-ended problems:

A few observations were made on how the various groups responded to being presented open-ended problems. Firstly, the private-school students, who had excelled in diligently writing down answers to any questions or prompts we wrote on the board, struggled to answer the creativity questions. In the elaboration prompt, where they were asked to draw a detailed picture around their initials, the private-school students disobeyed repeated commands to not talk to their neighbor and copy. Their teacher ended up going around the room, dictating potential drawing options they could produce. The other groups (public-school and rural village girls) also struggled to produce sufficient results on the creativity prompt. They, however, complained less and did obey the instructions to fill it out themselves. This does, however, question the validity of this exercise in measuring creativity levels, as opposed to capturing students' ability to write an exam efficiently.

When it came to the open-ended design prompt of creating a lamp structure, the students flourished in producing ideas. They were all able to readily draw something. And they were excited to do so – there was an audible gasp of excitement when we announced to the public-school students that they were now to design their own lamp. This appears to have been one of the few times when students were allowed to engage in such an open-ended exercise, based on an observation that the artwork on display in the private-school was of the fill-in-the-outline style.

TABLE I
SUMMARY OF SURVEY RESPONSES TO WHETHER STUDENTS HAD BUILT SOMETHING BEFORE AND IF YES, WHAT IT WAS

	Private-school	**Public-school**	**Girls Hostel**
Number (%) who had built something before	16/20 (80%)	14/15 (93%)	11/11 (100%)
Some examples cited	Hydraulic car using syringes, model volcano, science projects done in school	Paper-based objects: flower, boat, kite, etc.	Doll, flower, cloth, etc.

2) Surveys (Interest, Creativity, Confidence)

Pre-Survey Results:

Prior to the intervention, the private-school students reported higher confidence and perceived creativity than the public-school students. The public-school students reported an average creativity level of 6.9 and confidence level of 8.2, whereas the private-school students reported an average of 8.7 and 8.4, respectively. This is in spite of the fact that none of them had worked with such hardware tools before. Only a few of the students at the private-school cited having worked with some electronics before. And yet, similar to the dynamic captured at Ashesi, a private university in Ghana (Beem, 2021a), almost all survey respondents reported high values (between 8-10) for their confidence to design and build their own product prior to any training.

As seen in Table I, although the vast majority of students in each group cited experience with designing and building

https://doi.org/10.52202/073963-0026

objects, the examples cited seemed to come more from school-based projects for the private-school students and more from home-based craft-type projects for the public-school and girls hostel groups. This could, however, also have been influenced by the translation given to each group. If the translator provided ideas for what types of things they could list, that would likely have affected their responses.

Fig. 2 captures the creativity results, in the form of box-and-whisker plots to describe the distribution of responses for each cohort. Each of the three measures are depicted separately. Single-factor ANOVA tests reveal a statistically significant difference between the cohorts for fluency and flexibility, but not for elaboration. For fluency, $F(2,43) = 37.97, p = 3.16E-10$, for flexibility $F(2,43) = 5.77, p = 6.01E-03$, and for elaboration $F(2,43) = 0.12, p = 8.87E-01$. The private-school cohort scored significantly higher in fluency than the other groups, and the hostel girls cohort scored significantly higher in flexibility than the other groups. T-tests conducted between women and men disaggregations for each of the three creativity measures revealed no statistically significant difference ($p > 0.05$). Hence there was no significant difference in how the students responded to this assessment, based on their gender.

Based on the observations made to how the private-school students responded to this exercise, one interpretation of this is that due to their experience practicing writing exams under pressure, they were better positioned to produce a large quantity of ideas. As mentioned above, the private-school students kept talking to each other as they completed the questions, and the teacher even supported this, which suggests that these students are used to operating in a competitive/high-achievement mode, even in this case where no grade would be administered.

It is striking that in spite of this, the hostel girls cohort scored significantly higher in flexibility. Perhaps because they were in an environment that they associate more as a relaxing one than at school, they were able to tap into divergent thinking more readily. The public-school students noticeably struggled to write things down on this exercise, which perhaps could be attributed to the timing – it was right after their play period, and it was later in the day. This raises the question of the extent to which this test is an ability of their actual creativity versus their ability to focus and execute on written prompts. The following is a quote from Author 1's journal entry on 25 July 2019: *"Looking around as the [public-school] students progressed through the electronics and the creativity exercises, I felt sad to see that all groups were fitting into their respective "positions" on all the tests I was administering. The Non-Siddi boys, then the Siddi boys, then the Non-Siddi girls, then the Siddi girls. In that order. Without even looking at the data yet, I could see based on how vigorously they were writing or not, that that's the order they were falling in. Are the metrics incorrect to capture their abilities? Or are the systemic barriers truly holding people in their expected positions? If the latter, then I want to understand what those truly are and observe how the design-build activities can level the playing ground."*

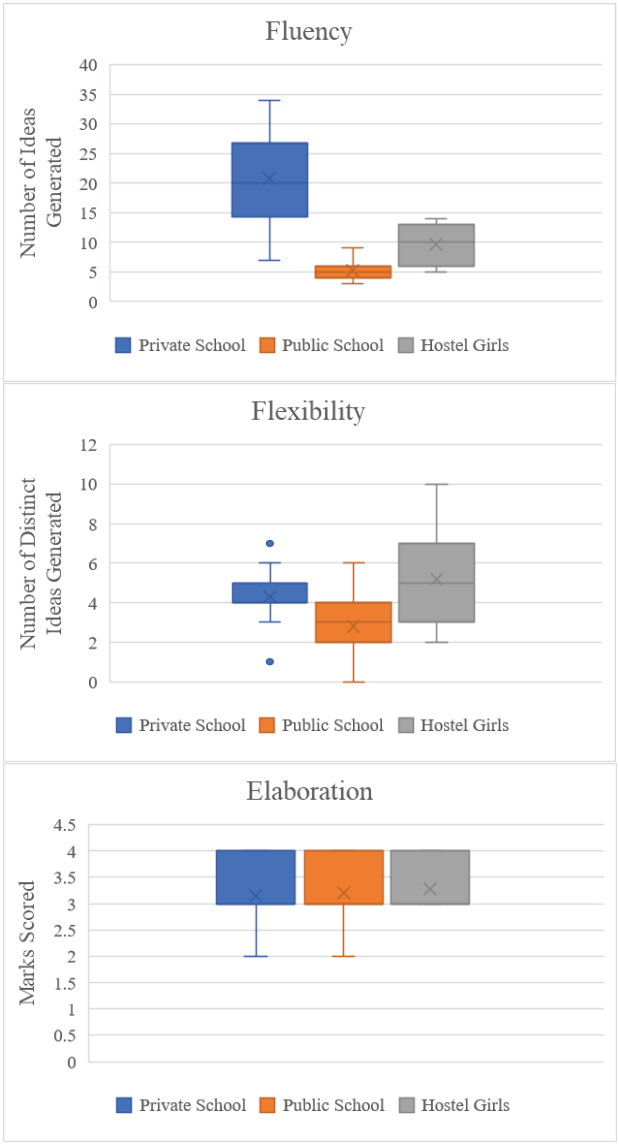

Fig. 2. Creativity dimension scores for each cohort

Pre-Post Changes:

Table II captures the results of the pre-post change analysis. Of the four metrics covered, interest in engineering was consistently the one that produced the most significant change across all groups. A large effect size was measured in all cases shown here. In aggregate, the interest in science also increased significantly. This was, however, largely driven by the public-school students. The private-school students experienced minimal change (p = 2.04E-01), which could be attributed to

https://doi.org/10.52202/073963-0026

TABLE II
RESULTS FROM T-TESTS AND HEDGE'S G TESTS OF THE PRE-POST CHANGE IN INTEREST, CREATIVITY, AND CONFIDENCE LEVELS PERCEIVED BY THE PARTICIPANTS AS A RESULT OF THE INTERVENTION

ALL STUDENTS		Mean	N	S.D.	Sig. (2-tailed)	|g|	Effect Size
Interest in Science	Pre	7.886	36	1.510	1.77E-03**	0.67	Medium
	Post	8.771	36	1.087			
Interest in Engineering	Pre	6.844	35	2.112	1.11E-06***	1.08	Large
	Post	8.743	36	1.336			
Creativity	Pre	7.939	35	1.767	1.87E-01	-	-
	Post	8.314	36	1.255			
Confidence	Pre	8.294	36	1.426	7.73E-01	-	-
	Post	8.257	36	1.633			

PUBLIC SCHOOL STUDENTS		Mean	N	S.D.	Sig. (2-tailed)	|g|	Effect Size
Interest in Science	Pre	7.400	15	1.957	2.88E-03**	1.12	Large
	Post	9.200	15	1.146			
Interest in Engineering	Pre	6.833	14	1.337	6.17E-04***	1.93	Large
	Post	9.067	15	0.961			
Creativity	Pre	6.929	14	2.018	6.40E-04***	1.15	Large
	Post	8.667	15	0.816			
Confidence	Pre	8.200	15	1.373	8.00E-01	-	-
	Post	8.333	15	1.543			

SIDDI STUDENTS		Mean	N	S.D.	Sig. (2-tailed)	|g|	Effect Size
Interest in Science	Pre	6.800	5	1.643	1.21E-01	-	-
	Post	8.667	6	1.506			
Interest in Engineering	Pre	6.800	5	1.643	1.61E-02*	2.02	Large
	Post	9.333	6	0.816			
Creativity	Pre	4.800	5	1.924	1.32E-02*	2.21	Large
	Post	8.000	6	0.894			
Confidence	Pre	7.167	6	1.169	2.86E-01	-	-
	Post	7.833	6	1.472			

*$p \leq 0.05$
**$p \leq 0.01$
***$p \leq 0.001$

the fact that they reported high interest (average 8.250) at the beginning, so there was not much upward progress to make.

The public-school students increased significantly and with large effect size for both interest in science and engineering. If this was one of their first experiences with hands-on STEM work, it is reasonable that this interest would have increased significantly. The public-school students also increased significantly and with large effect size in their perceived creativity levels. Although the public-school students in aggregate did not experience a statistically significant increase in confidence, the public-school females did (p = 7.00E-03).

The Siddi students similarly experienced significant gains from this training, especially in terms of interest in engineering and perceived creativity levels – both increased with statistical significance and large effect size. In fact, one of the Siddi males, who was likely considered a "slow learner" by typical school standards, is the one who reported the largest increases of all.

Although the gender divide appeared to be significant in the team dynamics for the private-school, no difference in statistical significance of pre-post changes were noted for the male and female private-school students. In the public-school, the males did increase in interest for engineering (p = 2.00E-05) whereas the females did not (p = 9.25E-02), and the females did increase in confidence (p = 7.00E-03) whereas the males did not (p = 2.88E-01).

As mentioned earlier, the public-school students objectively performed better than the private-school students in the training. Their pre-survey scores were also generally lower than what the private-school students reported. Hence it is reasonable that the pre-post changes experienced by the public-school students were generally more significant.

Open-Ended Questions:

In general, there was a strong sense of joy and excitement in the rooms as all groups engaged in the training sessions. This is also the main thing that came across in their open-ended responses to "How do you feel after this program?". For the private-school students, the top codes that emerged were "Happy" (8/21) and "Learned new things" (7/21). A few also mentioned "Empathy for skilled laborers" (3/21). One female student said, *"I feel very happy. All things that we did was interesting and new for us. We learnt many things and did hard work to complete these works."* For the public-school students, the top code that emerged was a mention of the item(s) they built (11/15). This suggests that they strongly associated their experience with the specific product created. The second most common code that emerged was "Enjoyment" (8/15) – similar to what the private-school students mentioned. One male student in this group said, *"I learn[ed] how to make a lamp and I enjoyed [it a] lot."*

3) Focus Groups

In their responses, the hostel females expressed significant joy, which is similar to what was captured on the surveys for the other two groups. They noted that they now had ideas for the science projects they'll have to do at school. And they noted that they enjoyed the process of doing this project in the teams - that doing it that way made the process easier.

When asked from multiple angles whether they thought they could replicate this or do other projects on their own later, they responded with a resounding *"yes"*. Most interestingly, the girls brought up the word "confidence" on their own, without being prompted. They self-described as having more confidence in their ability to do projects. One of the participants expanded on this by explaining that *"when you guided us, then we know that we also have skill, that we have to think outside, and we got the feeling that we also can do something."*

IV. DISCUSSION/CONCLUSION

A. Constructs/Framing

A number of observations were made on the constructs being employed. For one, the word "confidence" was interpreted differently than the authors expected from their own context. Confidence didn't seem to be a word that the interviewees readily used to describe their experience prior to the intervention. In fact, all translators struggled to convey the intention behind this in a standardized manner. However, the word organically appeared from the participants when they

https://doi.org/10.52202/073963-0026

described the change they experience from the training. Hence there is value in continuing to probe around the language and construct of confidence. It may be worth distinguishing intrinsic and extrinsic confidence. There is a difference between someone being confident because they've been told for their whole life that they are good at whatever and someone who although they may not have received this messaging still knows they can access a "toolbox" to address challenges they face. Work is ongoing to explore what constructs are relevant in the context of the first-year African engineering students (Beem, Ampomah, Takyi & Adomdza, 2023), of which self-efficacy may be one.

Interest is the construct that organically emerged as stakeholders described the starting point in their narratives. From the open-ended responses on the survey, joy, excitement, and pride all emerged. Hence these constructs can also be considered for further use in tool development. The role of community should also be considered in this exploration. The development of desired skills and mindsets does not happen in isolation. The students consistently conferred with each other before jumping into any task, no matter how small. Capturing the role of community and/or socialization may be an important element as well.

B. Role of stereotypes in the observed dynamics

The results revealed several interesting dynamics at play for the various student groups. Participants at the private-school tended to rate themselves higher than the public-school students prior to the training, but they performed worse. This suggests that due to societal messaging, they generally exist with a higher self-perception. One of the staff at the public-school used the term "slow learners" to describe their students. With such messaging, the public-school students may think less of their innate abilities.

Although all students increased significantly in their interest in engineering from this intervention, the public-school students are the ones who benefited in other dimensions as well – specifically in interest in science and creativity. The Siddi students specifically also increased significantly in their interest in engineering and perceived creativity levels. The female public-school students are the only disaggregated group that increased significantly in their confidence levels.

One of the Siddi males who appeared to often do work at his own pace and by himself, reported large increases in all questions. Such students may easily be categorized into the "slow learner" bucket but could easily benefit from small amounts of creative outlets for exploration.

Stereotype threat may be at play in inhibiting Siddi youth self-perception, based on societal messaging. Evidence for this could be drawn from the fact that Siddi youth tend to be comfortable when interacting in groups fully composed of Siddis. These results suggest that engineering skills-building activities can have a meaningful impact in breaking misperception and boosting self-perceptions.

Gender dynamics appeared significantly in the study- in the team formation stage, students self-selected along gender lines, but the nature of the activities appeared to break those dynamics down over time.

C. *Limitations*

A few factors should be borne in mind in interpreting the results here. There were slight differences in the grades, ages, and training implementation length between the three groups who received the training. This limits the directness of comparison between the groups. Also, small sample sizes, especially for the disaggregated groupings, limits the robustness of the respective statistical analyses.

D. Future Work

This mixed-method exploratory study has revealed significant insight to inform a refined implementation. Future work should consider other constructs to aptly align with the context and describe the phenomenon at hand. The role of gender can be examined more carefully as well. As further work is done to uncover the effects that engineering skills-building activities have on marginalized youth, learnings can be extended across contexts. Three specific goals are outlined here for next steps.

Goal 1: Assess the effects of this first training. Assess which, if any, of the tools that the participants have used post-training. And which, if any, additional fabrication projects have been carried out which may not have required the same tools. Which factors enabled them to do this (support staff, structure of school project/competitions, pressing need, interest, etc.)? Assess the extent to which their self-reported confidence still lives within them, versus being limited to the specific product they built and/or presence of support personnel to guide them.

Goal 2: Identify contextually-relevant language that captures something related to confidence. Conduct deeper interviews with community members to determine their levels of self-efficacy, talk through examples of people who they view as successful and determine what vocabulary they use to describe their actions, decisions and self-perceptions. This can be conducted for both students and adults.

Goal 3: Carry out a next stage of training with select participants. Provide additional skills-building training to select repeat participants. This training can cover additional aspects of the full CCB training which were omitted here, such as learning about the design process itself and then selecting a community need and collectively designing a solution to it.

Once more nuances of the local context are understood as well as an idea of which aspects of the training people most respond to, a control study can be carried out to elicit specific subareas of impact. This can be followed up by a longitudinal study to determine longer-term effects. Results should be considered by researchers seeking to support marginalized

https://doi.org/10.52202/073963-0026

youth globally.

Acknowledgment

The authors thank all the stakeholders on the ground who we had the pleasure of working with. Thanks to Rachel Campbell-Baier for assisting with the fieldwork. Finally, the authors also thank Ashesi University's Engineering Department for the travel support provided to conduct this field research.

References

Andrew Drain, Aruna Shekar & Nigel Grigg (2019). 'Involve me and I'll understand': creative capacity building for participatory design with rural Cambodian farmers, CoDesign, 15:2, 110-127, DOI: 10.1080/15710882.2017.1399147

Beem, H., Ampomah, C. O. A., Takyi, J. P. K., & Adomdza, G. (2023). A preliminary exploration of the relevance of self-efficacy, self-determination, and agency in describing the first-year African engineering students' experience. In 2023 ASEE Annual Conference & Exposition. https://peer.asee.org/42268

Beem, H. R. (2021a). The role of machine shop sessions in building confidence amongst first year engineering students in Ghana. In 2021 IEEE Global Engineering Education Conference (EDUCON), pp. 1469-1474.

Beem, H. R. (2021b). Exploring the Role of Project-Based Learning in Building Self-Efficacy in First-Year African Engineering Students. In 2021 ASEE Virtual Annual Conference Content Access. https://peer.asee.org/37161

Beem, H. R., & Jones, G. (2016). Harnessing creativity for design: tests in an introduction to engineering class. Procedia Engineering, 159, 322-325.

Childs, T. (2017). Creative Capacity Building in Uganda: Qualitative case research into the impact of CCB on individuals and communities. *Massachusetts Inst. Technol. D-Lab,* 1-13.

McWilliam, E., Dawson, S., & Tan, J. (2008). From vaporousness to visibility: What might evidence of creative capacity building actually look like? UNESCO Observatory Journal: Multi-disciplinary Research in the Arts, 1(3), 1-19.

MIT D-Lab, "Creative Capacity Building (CCB)", Online https://d-lab.mit.edu/innovation-practice/approach/creative-capacity-building-ccb Accessed on 04 September, 2023

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. American Psychologist, 52(6), 613-629. https://doi.org/10.1037/0003-066X.52.6.613

Taha, K. A. (2011). Creative capacity building in post-conflict Uganda (Master's Thesis, Massachusetts Institute of Technology, Department of Urban Studies and Planning). http://hdl.handle.net/1721.1/63238

https://doi.org/10.52202/073963-0026