



## **Project-Based Learning: A Correlational Study on STEM Identity and Engagement for Middle-Grade Students**

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This study examines the impact of Project-Based Learning (PBL) on STEM identity and engagement among middle-grade students in Bhutan. Although STEM education is incorporated into Bhutan's curriculum, student performance in STEM subjects remains poor necessitating pedagogical transformation. This longitudinal study employed a repeated measures experimental design, evaluating changes in STEM identity and engagement across three time points using validated survey instruments. The study involved 47 students from grades IX and X. Correlational analyses examined relationships within and between STEM identity and engagement subscales. Findings revealed a significant increase in STEM identity and engagement following the PBL intervention, although scores declined slightly in the final survey, indicating the need for sustained reinforcement. Although there was significant correlation within STEM identity and engagement, however, no statistically significant correlation was observed between STEM identity and engagement. These results suggest that while PBL effectively enhances STEM identity and engagement, instructional strategies might be required to establish a stronger correlation between the two constructs. Therefore, Educational policies in Bhutan should integrate systematic PBL frameworks, selected pedagogical support, and assessment approach to support link between STEM identity development and student engagement. Furthermore, Future research could explore long-term effects of PBL and incorporate mixed-method approaches to capture deeper insights.

**Keywords:** : project-based learning, STEM identity, engagement, correlation, analysis

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## **INTRODUCTION**

The global education system places significant importance on Science, Technology, Engineering, and Mathematics (STEM) education. Moreover, STEM plays a critical role in the ongoing reform of education systems for the development of nations. Similarly, Bhutan, as a developing country, has introduced relevant and timely STEM education into its curriculum (Kinley et al., 2021). Furthermore, the Bhutan Education Blueprint 2014–2024 underscores the importance of STEM education, stating that school curricula should actively promote the acquisition of innovation, creativity, business skill, and principles of peace and harmony as universal 21st-century skills (Ministry of Education [MoE], 2014). STEM education has played a pivotal role in educational reform, providing effective means to acquire knowledge, skills, and values (Kinley et al., 2021).

Although Royal Government of Bhutan and the Ministry of Education and Skills Development integrated STEM into the mainstream education program, students' results specifically in STEM remain poor. According to Kinley et al. (2021) over the years, the performance of Bhutanese students in mathematics and science has remained generally poor across all classes, particularly in Classes X and XII in national examinations, necessitating a transformation in the pedagogical approaches employed for teaching STEM subjects. Moreover, the pedagogy utilised is predominantly teacher-centred in the classes.

The Bhutanese education system emphasises science, mathematics, and ICT, with limited vocational and engineering components. Additionally problem-solving and innovation are integrated into core STEM subjects. The study of STEM is recognised as one of the primary learning areas in the Bhutanese curriculum leads to development of innovative and creative skills under the science and technology education required for the 21st century (Kinley et al., 2021). Additionally, the development of 21st Century skills include assessing critical thinking, perseverance, peer relationship, and relationships with adults (Ayers et al., 2020) are equally important.

In south Asian countries such as Nepal studies reported that PBL improved pedagogical practices and teacher professional learning when PBL is contextually adapted, however challenges pertain in scaling and sustaining implementation (Acharya, 2023). Although specifically in Bhutan educational policy focus on PBL to strengthen STEM education, no empirical studies explored its effect on middle-grade students' STEM identity and engagement. Recent research explored PBL's influence in enhancing conceptual understanding (Torres, 2024) necessitating the need to fill this contextual research gap.

## **LITERATURE REVIEW**

PBL is founded on constructivist theory, revolves around the premise that learners actively design knowledge through real and collaborative engagement with real-world activities (Krajcik & Blumenfeld, 2006). Recent research supports PBL significantly fosters engagement, motivation, and real-world knowledge in STEM contexts (Song et al., 2025; Santos et al., 2025), suggesting its potential that can facilitate significant engagement that may lead to development of STEM identity. However, there are no

study has methodically examined the relationship among STEM identity and engagement through PBL particularly within Bhutan's GNH-guided curriculum emphasizing atheoretical and empirical gap.

### **STEM identity**

This study was based on the ideas of identity by Carlone and Johnson (2007), which included three interconnected aspects such as performance, competence and recognition. Furthermore, they noted that an individual with strong science identity possesses required skills to perform for others with scientific practices such as effectively using scientific tools, demonstrating fluency in different forms of scientific communication, and interaction both formal and informal scientific environments. Strong STEM identity may be associated with academic performance (Seyranian et al., 2018). Competence is the next crucial aspect that defines how students associate with STEM activities or subjects (Grimalt-Álvarez et al., 2022). A person with strong identity is competent; exhibits meaningful knowledge and comprehension of science content and is motivated to understand the world scientifically (Carlone & Johnson, 2007). Recognition in STEM identity entails acknowledgment by others and self-perception related to STEM field. Starr et al. (2020) studied STEM identity through students' identification with individuals in STEM and their self-concept as members of the STEM community. Therefore, recognition in the STEM field can occur through self-perception and by others.

### **Engagement**

Engagement has four unique yet linked components: behavioural, emotional, cognitive, and social (Delfino, 2019; Fredericks et al., 2004; Wang et al., 2016). According to Sinatra et al. (2015), the concepts of cognitive engagement and behavioural engagement accord. The term behavioural engagement of the students refers to a multifaceted notion that describes how students behave in classroom activities, particularly when participating in school activities coupled with academic motivation (Hospel, 2016; Nguyen et al., 2018). Cognitive engagement in this study is limited to thinking about academic activities. The foundation of cognitive engagement is an investment in knowledge (Gao et al., 2020). Other facets of engagement include emotional engagement. Students' emotional responses to disciplines like science and general education are referred to as emotional engagement (Pekrun & Linnenbrink-Garcia, 2012). Emotional engagement can also relate to emotional stimulation (Sinatra et al., 2015). The final facet of engagement includes social engagement, where social engagement is any self-initiated, autonomous motor or oral performance directed toward another to start a social encounter, such as asking for aid or taking the adult by the hand, which was classified as social engagement (Ho et al., 2019).

### **STEM identity and engagement**

STEM identity is a student's understanding of themselves as a person who can perform and be in STEM field and STEM engagement consist of student's excitement and interest in participating in STEM domain (Ayers et al., 2020). There are numerous studies that support students STEM engagement leads to development of STEM

identity. Studies involving students in active STEM roles have shown that this enhances students' engagement in STEM and subsequently contributes to developing accurate perceptions of STEM roles consequently resulting in identity transformation fostering greater academic motivation (Kaplan & Flum, 2012; Stout et al., 2011). In a study on diverse youth participating in an outdoor environmental science program, Carlone et al. (2015) demonstrated that the activities had the capacity to stimulate participants' context-specific identity formation. Hence engagement in STEM to lead to STEM identity formation.

### **Impact of PBL on STEM Identity and Engagement**

It was hypothesised that employing intervention PBL would have positive changes in both subscales of STEM identity and engagement, it was perceived to correlate within and between one another. PBL, in the opinion of Krajcik and Blumenfeld (2006), is a form of contextual learning based on the constructivist tenet that students actively develop their knowledge. PBL enables students to formulate a question, develop hypothesis and an explanation, engage in discussion, and access own thoughts (Olivera, 2022). The five important components of a PBL experience identified by Krajcik and Blumenfeld (2006): a driving question, inquiry-based activities, collaboration, learning technology, and the production of a final public output. They also encourage collaborative work as solutions to the driving questions reflecting on ideas of experts solving the problem as a foundational PBL.

Owing to the student involvement and active engagement by the implementation of PBL it has got widespread benefits. Earlier studies showed the effect of PBL, that supported STEM student engagement (Eccles & Wigfield, 2002). Using of PBL presents learners with an avenue to formulate their own learning requirements and consequently empowering learners and are engaged who can solve problems (Bilbao et al., 2018). Moreover, Pan et al. (2019) demonstrated that the PBL contributes positively to maximising the motivation of students enabling to take part in the learning process. Therefore, there are many studies that demonstrated the positive effects of PBL within various areas of STEM education and student engagement. Studies including students in active STEM roles have revealed that this increases students' engagement within STEM and consequently leads to forming accurate perceptions of what STEM roles and it has also been shown that changing one's identity leads to higher academic motivation (Kaplan & Flum, 2012; Stout et al., 2011).

Although PBL enhanced students' thinking and active engagement in global contexts (Pangestu & Hidayah, 2024; Lara-Prieto et al., 2023). However, there are limited global studies explicitly evaluating STEM identity as a distinct construct linked to PBL in middle-grade schools leading to literature-gap for the global context and particularly for Bhutan. Therefore, this study examined the following questions:

1. How do the subscales of STEM identity correlate with one another in middle-grade Bhutanese student participating PBL?
2. How are the subscales of engagement interrelated in middle-grade Bhutanese students engaged in PBL?

3. How does STEM identity correlate with engagement across subscales in middle-grade students participating in PBL?

## **METHOD**

This study employed a longitudinal study. In longitudinal studies, each subject is measured repeatedly or continuously over an extended period, frequently a year or a decade (Caruana et al., 2015). Repeated measurements of an experimental design were used in this study to measure the same variables for the same set of participants throughout three time periods (Olivera, 2022). The same variable includes STEM identity and engagement measured three times. This study utilises a repeated measures experimental design to assess the effects of a PBL intervention over one and a half. Data were collected survey as pre-test, post-test, and follow-up stages, enabling analysis of within-subject variations and evaluating both immediate and sustained impacts, thereby enhancing internal validity. The suitability of repeated-measures design was guided by its acceptability in exploratory correlation in a small, context-relevant sample additionally suggesting sufficient power to assess changes within participants, though generalisability is integrally limited (Guo et al., 2013). Survey instruments were cautiously adapted to the Bhutanese context. In this study independent variable consists of the participation of the student in the intervention (PBL approach), whereas the dependent variables consist of STEM identity and engagement, the dependent variable was measured via survey administration. The surveys were administered three times: just before an intervention, shortly after the intervention, and one and a half months after the intervention's end later to assess retention and long-term impact. The total hours attended by each person was 25 hours that was 30 days and in a day 50 minutes. To address the challenges of response bias, survey questionnaire was worded neutrally. This approach confirmed that participants' responses were reliable rather than being influenced by prior experiences.

## **Sample**

Quota sampling is a non-probability method where researchers select participants based on specific characteristics to ensure population representation and research relevance (Adeoye, 2023). Quota sampling, a type of purposive sampling, is appropriate for this intervention-based study as it ensures proportional representation of key subgroups, enhancing the validity of correlation analysis. The participants in this study comprise of students from Class IX and X in one of the schools in eastern Bhutan since the study is about checking a correlational on STEM identity and student engagement for middle-grade students in Bhutan. The study's sample size consists of 47 students, with 26 students from Grade IX and 21 students from Grade X. Students' participation in the study was volunteer basis and students were not incentivised to participate in the study. For this particular study, entire grade IX and X students participated. Most of the students in grade IX and X students have taken general science subjects grounded in tenets of deep learning as opposed to the width of learning through active engagement of learners from fourth grade (Department of Curriculum and Professional Development [DCPD], 2022). Therefore, change in focus of tenets of deep learning emphasise on experiential learning such as Project-based learning in the Bhutanese context.

## **Research instrument**

### **STEM identity**

For this study, the Role Identity Survey for Science, Technology, Engineering, and Mathematics (RIS-STEM) scale was employed and was formulated by Carlone and Johnson (2007). This survey consists of STEM identity consisting of four interconnected constituents of performance, competence, and recognition. In addition, the recognition consists of recognition by self and recognition by others in the formation of STEM identity. The fourth component of interest was further added by Hazari et al. (2010), and it constitutes curiosity and desire to understand STEM. Each item in the survey was scored using a four-point Likert scale that ranged from "Strongly Disagree" to "Strongly Agree." However, for the subscale interest was replaced with STEM-CIS interest survey (Kier et al., 2014) survey was scored using a five-point Likert scale ranged from "Strongly agree" to "Strongly disagree". Since most of the intervention took place in science classes. STEM identity consists of three RIS-STEM subscales. The reliability and validity of STEM identity subscales were previously established by Carlone and Johnson (2007), Hazari et al. (2010), and Kier et al. (2014).

### **Engagement**

Engagement in this study focused on STEM. Within STEM gauging engagement in the context of this study was important as the intervention that is PBL took place in the science classes. For the engagement four subscales were included constituting of cognitive, behavioural, emotional, and social engagement (Olivera, 2022). The study used Wang et al. (2016) math and engagement scales. The survey consists of 33 items on the 5-pointed Likert scale. Additionally, the reliability and validity of the survey for the science and math engagement was established by Wang et al. (2016).

### **Research procedure and data analysis**

Prior to the intervention using a PBL, survey was administered that enabled to gather baseline data. Time points for survey administration were prior to the intervention unit, right after the intervention unit and the third survey will be completed two months after the intervention unit. The same teacher intervened in the class using PBL on the different topics such as blood circulation in the heart, changes of energy (Potential and Kinetic energy). The intervention commenced from the topic sources where students started designing model and prototype in their respective groups occasionally seeking guidance from the Science teachers. Finally, to evaluate the effect of PBL sustained over the period of time, ideally this could be measured over a longer period of time, however, due to time constraints it was measured keeping the time frame of two months.

A correlation analysis was run between STEM identity and engagement. The mean scores for individual items were calculated for STEM identity, due to the inability of the RIS-STEM subscales to be integrated to create a single identity score (Paul et al., 2020). At each stage, the relationship was evaluated within and between STEM identity, engagement subscales and the general engagement scale which consist of an average of all engagement scales together.

### Intervention

The intervention took place for one and a half months. The intervention on designing models or prototypes based on topic learnt was structured on the PBL approach developed by Krajcik and Blumenfeld (2006), in which students actively construct their understanding through interactive engagement and application of concepts. The intervention unit was formulated based on the ideas of the five important components of a PBL experience a driving question, inquiry-based activities, collaboration, learning technology, and the production of a final public output, identified by Krajcik and Blumenfeld (2006). Students designed prototype for different topics such as blood circulation in the heart, changes of energy (Potential and Kinetic energy) from locally available materials contextualizing the learning for instance for circulation of blood students designed using tiny rubber pipes as artery, veins and plastics as heart. Driving question include main inquiry such as for Blood Circulation in the Heart – How does the structure of the heart ensure efficient blood circulation throughout the body? For Changes of Energy – How is energy transformed from one form to another in everyday life? students in group used to gathered additional information from internet. Students gathered resources and designed prototype in groups; however, students wrote reflections on their respective prototypes individually. These reflections were consequently evaluated by researchers for assessment purposes.

### Scales

The reliability of all survey subscales that were administered thrice was consecutively measured. STEM identity consists of RIS-STEM subscales of competence, self-recognition, and recognition by others and STEM-CIS interest survey (Kier et al., 2014). To measure engagement consists of scales of behavioural engagement, cognitive engagement, social engagement and emotional engagement that were examined separately and then combined to measure general engagement (Wang et al., 2016). Reliability analyses were run for Cronbach's alpha being calculated for each subscale of the survey that was administered thrice. Factor analysis was deemed unnecessary for both measures of STEM identity and engagement owing to prior validation in multiple studies (Paul et al., 2020; Wang et al., 2016). The reliability coefficients of four subscales of STEM identity across the three specified periods are listed in Table 1, while the reliability coefficients for all engagement subscales are provided in Table 2.

### FINDINGS

The tables below show the reliability (Cronbach's alpha) for STEM identity subscale, engagement subscale and overall engagement across all three time periods.

Table 1  
Reliability (Cronbach's alpha) for STEM identity subscale across all three time periods.

Subscale	Time 1	Time 2	Time 3
Competence	0.83(N=47)	0.80(N=47)	0.82(N=47)
Recognition by others	0.85(N=47)	0.89(N=47)	0.89(N=47)
Self-recognition	0.83(N=47)	0.87(N=47)	0.90(N=47)
Interest	0.76(N=47)	0.80(N=47)	0.85(N=47)

Table 2

Reliability (Cronbach's alpha) for each engagement subscale and overall engagement across all three time Periods.

Subscale	Time 1	Time 2	Time 3
Cognitive	0.33(N=47)	0.28(N=47)	.665(N=47)
Behavioural	0.60(N=47)	0.57(N=47)	.718(N=47)
Emotional	0.88(N=47)	0.80(N=47)	.829(N=47)
Social	0.55(N=47)	0.53(N=47)	.640(N=47)
General	0.86(N=47)	0.83(N=47)	.884(N=47)

The reliability analysis demonstrated significant and consistent internal consistency for all STEM identity subscales across three time periods. Competence showed consistently high reliability ( $\alpha = 0.80-0.83$ ), recognition by others ( $\alpha = 0.85-0.89$ ), and self-recognition showed high levels ( $\alpha = 0.83-0.90$ ). Interest exhibited acceptable to good reliability ( $\alpha = 0.76$  to  $0.85$ ). Engagement subscales demonstrated more changes: cognitive reliability was low initially however acceptable at Time 3 ( $\alpha = 0.67$ ), behavioural exhibited moderate to acceptable ( $\alpha = 0.57-0.72$ ), emotional remained acceptable ( $\alpha = 0.80-0.88$ ), and social was low to moderate ( $\alpha = 0.53-0.64$ ). Overall engagement was consistently high ( $\alpha = 0.83-0.88$ ).

### Descriptive Statistics

The descriptive statistics such as mean, standard deviation, and sample size for each subscale of both constructs, STEM identity and engagement from each time point (3 times) can be found in the tables given below.

Table 3

Descriptive statistics for STEM identity subscales for time 1, 2 and 3

Subscales	N	Mean (Time1)	SD (Time1)	Mean (Time 2)	SD (Time2)	Mean (Time 3)	SD (Time3)
Competence	47	3.01	0.422	3.29	0.387	3.04	0.374
Self-recognition	47	3.20	0.486	3.38	0.469	3.15	0.511
Recognition by others	47	2.92	0.536	2.95	0.500	2.91	0.493
Interest	47	4.16	0.430	4.30	0.436	4.14	0.474

As reported in Table 3 for first survey mean for subscale recognition by others was the lowest, and mean for subscale competence in second lowest. Means for subscales Self-recognition by others and interest were reported as higher than the other two within STEM identity.

Table 4

Descriptive statistics for engagement subscales for time 1, 2 and 3

Subscales	N	Mean (Time1)	SD (Time1)	Mean (Time2)	SD (Time2)	Mean (Time 3)	SD (Time3)
Cognitive	47	3.39	0.323	3.56	0.348	2.99	0.630
Behavioural	47	3.69	0.432	3.86	0.410	3.77	0.477
Emotional	47	3.76	0.697	4.07	0.531	3.90	0.609
Social	47	3.62	0.531	3.80	0.513	3.83	0.519
General	47	3.62	0.390	3.83	0.353	3.62	0.444

In Table 4 for the first survey engagement subscale mean for cognitive engagement was the lowest followed by the social and general engagement, average of all engagement scales combined. Mean for emotional engagement was highest.

After the second survey administration, Table 4 demonstrated a higher mean across all

engagement subscales compared to first survey, indicating increased levels of engagement. Similarly, Table 3 indicated that the second survey reported higher mean scores across all STEM identity subscales compared to the first survey. After the third and final survey administration, all subscales for the STEM identity subscales decreased compared to the second survey in Table 3. Table 4 reported that all subscales for engagement in decreased during the third and final survey compared to the second survey.

### Correlation among scales

Correlation among scales was examined to analyse the relationship within and between STEM identity and engagement. Pearson correlation coefficients were employed to evaluate subscales within and between both constructs, including the combined general engagement scale, across each survey administration. Pearson correlations were selected for their applicability in parametric analysis with Likert scale data, although reasons such as small sample sizes, unequal variances, and potential non-normal distributions in this study (Norman, 2010). The correlation focused on exploring the relationship within and between STEM identity and engagement scales

Correlational analyses were run among the respective subscales for each measure. For the analysis, significance was assessed at the .01 level for the time 1. For time 1 stem competence showed a statically significant positive correlation with recognition by others, self-recognition and interest except cognitive engagement. However, stem competence negatively correlated with behavioural, emotional, social and general engagement. Recognition by others showed a statically significant positive correlation with self-recognition, interest and negatively correlated with cognitive, behavioural, emotional, social and general engagement. Self-recognition has a statistically significant positive correlation with interest except with behavioural, emotional, social and general engagement, however, it is negatively correlated with cognitive engagement. Interest showed a negative correlation between cognitive and behavioural engagement except for emotional, social and general engagement. Cognitive engagement showed a statistically significant positive correlation with behavioural, emotional, social and general engagement. Behavioural engagement showed a statistically significant positive correlation with emotional and general engagement except for social engagement. Emotional engagement showed a statistically positive correlation with social and general engagement and finally social engagement showed a statically positive correlation with general engagement.

Table 5

Correlations between all subscales of STEM identity and engagement (Time 1)

Measures	1	2	3	4	5	6	7	8	9
Stem competence	1	.612**	.408**	.645**	.073	-.061	-.018	-.058	-.028
Recognition by others		1	.653**	.424**	-.109	-.068	-.057	-.088	-.096
Self-recognition			1	.531**	-.115	.154	.202	.032	.137
Interest				1	-.051	-.071	.205	.014	.086
Cognitive					1	.377**	.476**	.381**	.670**
Behavioural						1	.569**	.256	.726**
Emotional							1	.377**	.898**
Social								1	.638**
Overall									1

\*\* $p < .01$

For time 2 for the analysis, significance was assessed at the .05 level. For time 2 stem competence showed a statistically significant positive correlation with recognition by others, self-recognition and interest except for cognitive, behavioural, social and general engagement. However, stem competence showed a negative correlation with emotional engagement. Similarly, recognition by others exhibited a statistically significant positive correlation with self-recognition and interest, except for the behavioural, social and general engagement. However, recognition by others showed a negative correlation with cognitive and emotional engagement. Self-recognition showed a statistically significant positive correlation with interest and social engagement except for cognitive, behavioural, emotional and general engagement. Interest showed a negative correlation with emotional engagement except for cognitive, behavioural, social and general engagement. Cognitive engagement showed a statistically positive correlation with behavioural and general engagement except for emotional and social engagement. Behavioural engagement showed a statistically positive correlation with emotional, social and general engagement. Emotional engagement showed a statistically positive correlation with social and general engagement. Finally social engagement has a statistically positive correlation with general engagement.

Table 6

Correlations between all subscales of STEM identity and engagement (Time 2)

Measures	1	2	3	4	5	6	7	8	9
Stem competence	1	.693**	.580**	.536**	.089	.155	-.065	.043	.048
Recognition by others		1	.661**	.461**	-.002	.179	-.085	.104	.044
Self-recognition			1	.610**	.202	.153	.081	.292*	.218
Interest				1	.012	.102	-.071	.080	.024
Cognitive					1	.324*	.256	.249	.523**
Behavioural						1	.653**	.620**	.847**
Emotional							1	.535**	.866**
Social								1	.786**
Overall									1

\*\* $p < .01$  \* $p < .05$ 

For time 3 for the analysis, significance was assessed at the .05 level. For time 3 stem competence showed a statistically significant positive correlation with recognition by others, self-recognition and interest except with cognitive, emotional, social and general engagement. Correspondingly, recognition by others statistically significant positive correlation with self-recognition and interest except for cognitive, behavioural, emotional, social and general engagement. Self-recognition showed a statistically significant positive correlation with interest and emotional engagement except for cognitive, behavioural, social and general engagement. Interest showed a negative correlation with social engagement. Cognitive engagement exhibited a statistically significant correlation with behavioural, emotional, social and general engagement. Behavioural engagement exhibited a statistically significant positive correlation with emotional, social and general engagement. Similarly, emotional engagement showed a statistically significant positive correlation with social and general engagement. Finally, social engagement showed a statistically positive correlation with general engagement.

In summary, across 3 time periods, stem competence consistently depicted a positive correlation with recognition by others, self-recognition, and interest, while exhibiting a

positive correlation with cognitive, behavioural, emotional and social engagement. Recognition by others exhibited a positive correlation with self-recognition and interest however showed a negative correlation with emotional engagement. Self-recognition showed a positive correlation with interest and emotional engagement. Interest exhibited a mixed correlation with other engagement types. Cognitive engagement positively correlated with other engagement, whereas emotional engagement correlated primarily with social and overall engagement. Social engagement positively correlated with overall engagement consistently. Hence, all subscales of identity displayed significant, positive correlations with one another since they were measuring components of the same construct. Similarly, all subscales of engagement, including the combined scale of overall engagement, exhibited a significant, positive correlation with one another.

Table 7

Correlations between all subscales of STEM identity and engagement (Time 3)

	1	2	3	4	5	6	7	8	9
Stem competence	1	.584**	.578**	.484**	.045	.127	.230	.084	.154
Recognition by others		1	.676**	.509**	.097	.139	.284	.166	.218
Self-recognition			1	.597**	.095	.032	.305*	.136	.186
Interest				1	.098	.049	.112	-.070	.066
Cognitive					1	.587**	.576**	.486**	.852**
Behavioural						1	.517**	.454**	.787**
Emotional							1	.394**	.801**
Social								1	.722**
General									1

\*\* $p < .01$  \* $p < .05$ 

## DISCUSSION

This research investigated the potential correlations and changes in middle school STEM students' identity and engagement during and after PBL experiences. Earlier studies demonstrated the impact of active learning techniques, like PBL, that supported STEM student engagement (Eccles & Wigfield, 2002). Studies including students in active STEM roles have revealed that this increases students' engagement within STEM and consequently leads to forming accurate perceptions of what STEM roles and it has also been shown that changing one's identity leads to higher academic motivation (Kaplan & Flum, 2012; Stout et al., 2011). The findings of the present study align to assertions that PBL strengthens aspects of STEM identity and engagement by showing significant correlation within STEM identity subscales and within engagement subscales. These findings align with those of Carlone et al. (2015), who demonstrated that the activities effectively fostered participants' context-specific identity formation. This finding aligns with principles of Social Cognitive Theory, that states that degree of mastery experiences and participation in authentic tasks strengthen self-efficacy and identity formation (Bandura, 1997; Schunk & DiBenedetto, 2020). This concurrence suggests that similar mechanisms that reinforce the argument that such activities contribute meaningfully to identity development within specific contexts.

There are adequate studies that demonstrated the positive effects of PBL within various areas of STEM education and student engagement. Therefore, this study hypothesised

that there would be significant correlations between all aspects of STEM identity and engagement, correlation analyses were carried out at every stage, assess this relationship. For Time 1, STEM competence positively correlated with recognition by others, self-recognition, and interest, but negatively with behavioural, emotional, social, and overall engagement. STEM subscales such as recognition by others and self-recognition followed similar patterns, with positive correlations for interest and negative for other engagements. Cognitive engagement positively correlated with all engagement subscales.

For Time 2, STEM competence and recognition by others positively correlated with self-recognition and interest, however negatively correlated with emotional engagement. Additionally Self-recognition showed positive correlations with interest and social engagement. For Time 3, similar patterns were observed, with STEM competence positively correlating with recognition by others, self-recognition, and interest, and there were positive correlations among engagement types. STEM identity exhibited positive correlations with its subscales, similarly engagement with its respective subscales.

The findings of the study are in line with previous study that acknowledged that participation in PBL maximises student engagement (Carrabba & Farmer, 2018; Duke et al., 2021). The findings of this study align with previous research highlighting the impact of problem-based learning (PBL) on STEM student engagement (Eccles & Wigfield, 2002). PBL enables learners to identify their own learning needs, fostering empowerment, engagement, and problem-solving skills (Bilbao et al., 2018). This reflects Self-Determination Theory, as PBL environments support students' psychological needs for autonomy, competence, and relatedness, thereby strengthening intrinsic motivation and engagement (Niemic & Ryan, 2009). This reinforces PBL's role in promoting active learning and skill development.

#### **LIMITATIONS AND RECOMMENDATIONS**

Future research can adopt a mixed methods methodology could be better. Conducting interviews with students and teachers could reveal their perspectives on the most effective parts of the intervention. Employing mixed-methods could lead to a novel line of inquiry in this specific area. This study had numerous limitations related to the sample. Firstly, the sample size was limiting factor, since in quantitative research, employing survey a larger sample is chosen. The purposive and convenience sample for this study was limited by being conducted with only limited number of students in two grades.

Modifications and change of the study's design could have produce more significant and definitive results thereby by enhancing its precision. This study did could have employed an experimental design. For this study results were measured over extended period of time for only one group, and the sample was not randomly chosen. A true experimental design would have randomized participants into either a research or control group, measuring outcomes for both, and then evaluating them to check the intervention's impact on STEM identity and student engagement.

The findings of this study can aid curriculum designing and teacher professional development. A sustained, authentic PBL practices across STEM curricula to strengthen both identity formation and engagement must be implemented. Curriculum designer needs to emphasise to integrate real-world problem contexts, collaborative inquiry, and iterative design, leading to repeated mastery of opportunities that build competence and recognition. Theoretically, the study led to STEM identity research by exhibiting that identity–engagement associations are multifaceted and may be different across time. This underscores the value of employing dynamic, context-relevant models when examining how students internalise STEM roles and competencies.

### CONCLUSION

Despite ongoing efforts by Ministry of Education and Skills Development, STEM performance among Bhutanese students remains poor, demanding a transformation in the pedagogical approaches employed for teaching STEM subjects. Moreover, the pedagogy used are teacher-centred in the classes. Therefore, this study examined the impact of project-based learning (PBL) on STEM identity and engagement in middle-grade students. The findings demonstrated PBL fosters STEM identity by enhancing students' performance, competence, recognition and interest and also promoted engagement across cognitive, behavioural, emotional, and social engagement. Correlation with STEM identity and engagement was significant, however, especially correlation between STEM identity and engagement was not statistically significant. These results emphasise PBL's potential in fostering STEM identity and engagement leading to effectiveness of active learning strategies. Given Bhutan's emphasis on STEM related education, incorporating PBL into instructional practices could enhance student learning experiences. This study adds to the expanding body of research supporting PBL as an effective pedagogical approach in STEM education.

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