

# Brick-by-Brick: Enhancing Creativity and Problem-Solving in Under-Resourced Schools Through LEGO Interventions

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**ABSTRACT:** This study examines the effects of traditional LEGO brick interventions on creativity and problem-solving among primary school students from low socio-economic backgrounds in under-resourced Indian schools. While extensive research has investigated LEGO robotics in Western contexts, limited empirical evidence exists regarding the utilization of conventional LEGO bricks in developing countries. Creativity, conceptualized by Torrance as the ability to generate novel ideas and relationships, and problem-solving, defined as the application of higher-order cognitive functions to achieve goals, are critical skills often underdeveloped in India's rigid, instruction-focused education system. This research employs a structured "Brick-by-Brick" intervention with 3rd and 4th-grade students, utilizing the Alternative Uses Test (AUT) as a pre- and post-intervention measure of creativity. It is hypothesized that participants will demonstrate significant gains in creativity and problem-solving scores following the intervention. By addressing gaps in context, population, and longitudinal research, this study contributes to the evidence base for low-cost, scalable pedagogical tools that foster 21st-century skills in socioeconomically disadvantaged educational settings.

**KEYWORDS:** LEGO Bricks, Creativity, Problem-Solving, Socio-Economic Status, Alternative Uses Test (AUT).

## ■ Introduction

This research paper aims to understand the improvement traditional LEGO bricks can make to creativity and problem-solving in under-resourced schools in India, with students and parents belonging to a low socio-economic status. The term creativity was defined by Torrance March as "the capacity to detect gaps, propose various solutions to solve problems, produce novel ideas, re-combine them, and intuit a novel relationship between ideas."<sup>1</sup> For this research, the term "problem solving" is established as "the process by which individuals attempt to overcome difficulties, achieve plans that move them from a starting situation to a desired goal, or reach conclusions through the use of higher mental functions, such as reasoning and creative thinking."<sup>2</sup> While the present study focuses on creativity as measured by the AUT, references to problem-solving are framed as related cognitive processes supported by task design rather than as a directly measured outcome using a validated problem-solving instrument. Finally, according to the American Psychology Association, socioeconomic status "encompasses not only income but also educational attainment, occupational prestige, and subjective perceptions of social status and social class. SES encompasses quality-of-life attributes and opportunities afforded to people within society and is a consistent predictor of a vast array of psychological outcomes."<sup>3</sup>

Traditional schools in India follow a rigid curriculum, with little to no freedom given to the teachers to improve the quality of education. Although there has also been some priority toward a holistic education by the Indian government, which highlights the importance of the environment, there has been little action taken towards the enhancement of creativity and problem-solving skills. Additionally, traditional schooling fo-

cuses on well-structured instructions, which directly hinders problem-solving and creativity. A majority of LEGO-based research is carried out using LEGO robotics, while very little research uses conventional LEGO bricks [such as]<sup>4</sup>. A few attempts have been made to define the relationship between creativity and LEGO bricks. One study showed that using pre-established, instruction-based LEGO kits has an inverse effect on creativity. This 90-minute study was conducted with 136 undergraduate college students and aimed at differentiating the effects of ill-defined vs. well-defined tasks on creative thinking.<sup>5</sup>

Another study at Canterbury Christ Church University College explored the positive correlation between limiting the number of LEGO bricks used and creativity.<sup>6</sup> The correspondence between LEGO and problem-solving has not been explored to the same depth as the one between creativity and LEGO. Previous research on this topic ranged from using LEGO with 3rd-grade students to higher education learners. For example, a study conducted with 40 elementary school children saw an increase in mean scores from 9.22 (pre-intervention) to 12.2 (post-intervention). Whereas, in a study conducted in China, the use of LEGO has been used by engineering students to heighten problem-solving.<sup>7</sup>

While some studies provide successful primary research, multiple pieces are missing in the research. Firstly, many studies have taken place in Western contexts, China,<sup>8</sup> and Hong Kong, but no study related to traditional LEGO bricks, creativity, and problem-solving has been conducted with the Indian population (adults or children). Secondly, this research also aims to work with students from a lower socioeconomic background. A majority of studies are based in private schools, such as the

D1 district in Iran.<sup>9</sup> Additionally, a longitudinal study has not been conducted to explore the effects of creativity and problem-solving using LEGO bricks. The research, which was conducted for younger students in Tabriz, Iran, aimed to discover the advantages of using Lego in science.<sup>10</sup>

With the rise of artificial intelligence, creativity and problem-solving are more important than ever. Artificial intelligence can help conduct everyday tasks, but we need these skills to build originality. Students in private schools, studying in international programs, still might have the opportunity to learn with a holistic education, but children belonging to a lower socioeconomic status have no way to learn these important life skills. Moreover, these skills will help them excel in different fields that require a certain way of thinking. If the Lego toolkits do improve creativity in lower socioeconomic backgrounds, the goal of the study is to give access to the toolkits to multiple government schools and education-focused NGOs.

As a result, it is hypothesized that students in under-resourced Indian schools will demonstrate significantly higher scores on the Alternative Uses Test (AUT) after participation in the traditional LEGO-based intervention (Brick-by-Brick) compared to their baseline scores.

## ■ Methodology

### *Participants:*

This research aimed to study whether exposure to the 8 Lego problem-solving and creativity toolkits over 8 days leads to significant improvement in participants' (3rd and 4th graders, aged 11-12 years) problem-solving abilities and creative thinking, as measured by the Alternate Usage Test.

Students aged between 11 and 12 years of age (3rd & 4th grade) were recruited for this study. Ensuring their residence in Mumbai (India), selected students were from lower SES (the children participating were either paying less than ₹15,000(\$174) in yearly fees, or were sponsored by the Teach For India Foundation). Recruitment was undertaken through a government school in Mumbai, and a convenience sampling strategy was used to include an equal number of boys and girls. An important criterion for consideration was a lack of previous exposure to LEGO bricks. Participants were given the option to be a part of the study by the principal as a free after-school activity.

The data was gathered from the school and parents of the children through a demographic survey and past exposure to Lego bricks of the children. The Lego bricks were assembled into 8 unique kits. Each kit had its own difficulty and required the students to work together in groups of 4-5 to build creativity and solve problems.

### *Materials and Measures:*

The first toolkit was built to promote creativity among learners. This was done to try to educate students using a holistic curriculum. This type of education would not only improve creativity but also allow the students to enjoy the learning process.

- **Storytelling with Bricks:**
  - The first kit, “Storytelling with Bricks”, Figure 1, helped students get a feel of the pieces through building objects and creating stories as a group.



Figure 1: Storytelling with Bricks.

- **Stability Test:**
  - Next, the students were made to perform a stability test as shown in Figure 2. The students built a bridge-like structure with the stands 6 inches apart. After this, a one-kilogram weight was placed on the structure to check its integrity.



Figure 2: Stability test.

- **Drawing to Lego:**
  - Thirdly, the “Drawing to Lego”, Figure 3, activity was introduced. This consisted of students drawing anything they could imagine and converting that image into a tangible and 3-dimensional structure made of Lego.



Figure 3: Drawing to Brick Models.

- **Non-functional to functional:**
  - For toolkit 4, the students received cars and planes, which were incomplete and 'non-functional' as seen in Figure 4. The activity aimed to fix these objects to the best of the students' ability.



Figure 4: Fixing Non-Functional Objects.

- **Instructions to Object:**
  - Next, learning was incorporated into an activity by teaching the students the intricacies of the concept of 'inventions' (Figure 5). After learning what inventions are, the candidates start building a unique invention that hasn't been built before.



Figure 5: Teach and Build.

- **2-D to 3-D:**
  - For activity 6, the toolkits contained cards with pictures of different shapes on them, which can be seen in Figure 6. The goal of the activity was to make the shapes into objects made of Lego.



Figure 6: 2-D to 3-D.

- **Lego Relay:**
  - The next day, the students performed a Lego relay as shown in Figure 7. In this exercise, each group member built half of an object and passed it to the next member. The new member has to add to that object without communicating with other members. This process continued until every member worked on every object.



Figure 7: Brick Relay.

- **Rube Goldberg Machine:**
  - Lastly, the candidates took part in a culminating activity, in which they built a Rube Goldberg Machine (Figure 8). The objective was to build a ramp to take a marble from the top to the bottom. The students worked creatively on balancing the ramp perfectly to align with the wooden block bases.



Figure 8: Rube Goldberg Machine.

To quantify the data received pre- and post-testing, the Alternative Use Test (J.P. Guilford) was used. The purpose of this test is to generate useful and original uses for everyday objects. The Alternative Usage Test is used to measure an individual's creativity. The goal of the test is to name as many possible unique uses for 4 regular objects (a brick, a newspaper, a hanger, and an envelope). The test is scored based on 4 aspects: originality, fluency, categories, and elaboration.

Multiple software applications were used during this study. Canva played an important role in creating the design for the toolkits. Microsoft software was also used to digitize the data from the Alternative Use Test. Moreover, studio.io was used to list the Lego bricks needed and to create the instruction manuals for some of the activities.

### **Ethical Considerations:**

Permission to conduct the study was obtained from the school administration. Written parental consent and verbal student assent were secured prior to participation. Participation was voluntary, and students were informed that they could withdraw at any time without penalty. All data were anonymized prior to analysis.

### **■ Procedure**

The process began by brainstorming different ideas for the activities in the toolkit. 12 possible ideas for toolkits were listed. Next, each toolkit was broken down into the following categories: materials required, aim, and procedure. After analyzing each one, the 8 most effective toolkits were chosen based on the skills the kit develops. Then, the design for the boxes was created, within which the Lego bricks, a guide, and other miscellaneous items were included. These kits were then assembled one at a time with bricks, sand timers, and miscellaneous items into the boxes; the kits were also checked multiple times to ensure no box was incorrectly assembled. Next, the pretest was conducted using the Alternative Use Test. The students were given 2 minutes per category (newspaper, brick, envelope, hanger). To accommodate language diversity, the AUT instructions were read aloud with clarifications provided in Hindi when needed. Students were permitted to respond in either Hindi or English, and responses were later translated where necessary for scoring. For the next 8 days, each of the different kits was deployed in order.

Each activity was given an average time of 1 hour in the same classroom. There were 2 teachers present on behalf of the school. These teachers were given the role of making sure the class was quiet when the instructions were being given. The teacher-to-student ratio was 1:20. All instructions were given in the toolkit and were read out as given in the toolkit.

### **Design:**

An experimental research design was used. The independent variable was the use of the Brick-by-Brick toolkits. The dependent variables were creativity and problem-solving measured through the Alternative Use Test. There were multiple control variables that were kept constant during the pre- and post-test and the study period. The first control variables were the age, grade, and socio-economic status of the students; these were major constants during our study. Next, the variables in the school were kept constant through the location and time of day of the study. Moreover, the duration of the study on each day was averaged at 1 hour.

### **Data Analysis:**

A Paired Sample T-Test was used to compare the results between the pre-test and the post-test. First, the data was gathered on an Excel sheet to tabulate all of the results. To analyze the data, JASP software was used. Additionally, data integrity was used throughout the entire process. During the pre- and post-test, no talking between participants, teachers, or the instructors was permitted unless a relevant question was asked.

There were a few results that could not be used due to reasons that were not controlled by the researchers. A few questionnaires were nameless, which prevented them from being used as a result. Another group of students was present for only the pre-test or post-test. This meant no change in creativity could be observed.

Standard AUT scoring conventions were used to score the responses of the participants in four dimensions, namely originality, fluency, categories (flexibility), and elaboration. Two independent raters were trained on the same scoring rubric and sample answers before the scoring. The differences would be discussed and agreed upon. The score on originality was determined using the infrequency of responses statistically in the sample as the measure, and category score as the number of conceptual groupings (distinct) represented.

### **■ Results**

Students in under-resourced Indian schools demonstrated significantly higher scores on the Alternative Uses Test (AUT) following participation in the traditional LEGO-based intervention, Brick-by-Brick, compared to their baseline scores. The AUT assesses creativity by requiring participants to generate multiple solutions to a single problem across four dimensions: originality (uniqueness of responses), fluency (number of ideas), categories (range of ideas), and elaboration (level of detail). The study included  $n = 30$  participants, with a mean age of 10.20 years ( $SD = 0.961$ ). Measures of skewness and kurtosis fell within the acceptable range, indicating normality of the sample distribution. A paired-sample t-test was conducted, confirming that the differences observed were statistically significant. Given the sample size and normal distribution, the results can be considered representative of the target population. Of the students initially recruited, 30 participants provided complete matched pre- and post-test data and were included in the final analyses; incomplete or unmatched responses were excluded.

**Table 1:** Descriptive Statistics for Age. The table shows the statistics for the age range of 9-12.

Statistic	Value
Mean	10.20
Standard Deviation	0.96
Skewness	0.07
Standard Error of Skewness	0.43
Kurtosis	-1.14
Standard Error of Kurtosis	0.83
Minimum	9.00
Maximum	12.00

Note:  $N = 30$ .

The final sample consisted of 30 students enrolled in 3rd and 4th grade, ranging in age from 9 to 12 years ( $M = 10.20$ ,  $SD = 0.96$ ).

In this experiment, each participant completed the AUT (Alternative Uses Test) twice, before and after using the Brick-by-Brick Toolkits. There were a total of 8 kits, which consisted of the following:

- Storytelling with Bricks
- Stability Test
- Drawing to Lego
- Non-functional to functional

- Instructions to Object
- 2-D to 3-D
- Lego Relay
- Rube Goldberg Machine

Measure 1	Measure 2	t	df	p
Pre-test Sum_o	Post-test Sum_o	-4.891	29	< .001
Pre-test Sum_f	Post-test Sum_f	-7.360	29	< .001
Pre-test Sum_c	Post-test Sum_c	-5.152	29	< .001
Pre-test Sum_e	Post-test Sum_e	-1.216	29	.117

Although no formal correction for multiple comparisons was applied due to the exploratory nature of the study, three of the four AUT subscales demonstrated p-values below .001, which would remain significant under conservative correction procedures.

Given the exploratory and classroom-based nature of this study, statistical inference focused on within-subject comparisons using paired-sample t-tests. While effect sizes and confidence intervals are recommended for interpreting magnitude, the present analysis emphasizes statistical significance and directionality of change. Future work will incorporate full descriptive statistics and standardized effect size estimates to support meta-analytic comparison.

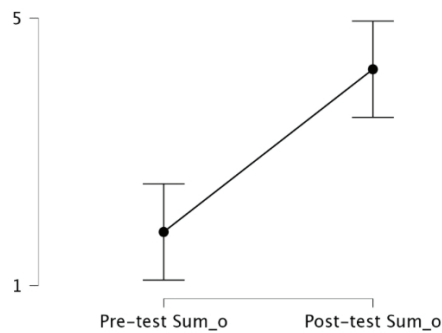
For all tests, the alternative hypothesis specifies that Measure 1 is less than Measure 2. For example, Pre-test Sum\_o is less than Post-test Sum\_o.

Sum\_o: Sum of all originality scores

Sum\_f: Sum of all fluency scores

Sum\_c: Sum of all categories' scores

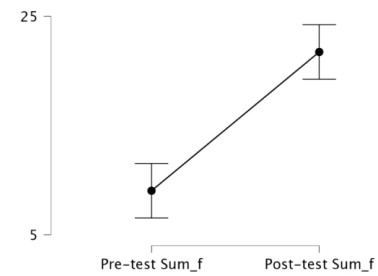
Sum\_e: Sum of all elaboration scores



**Figure 9:** Comparison of the originality pretest and post-test. Shows the increase in originality from pre-test to post-test.

Comparison of the average test score in the originality pretest and post-test (before and after using the Brick-by-Brick toolkits).

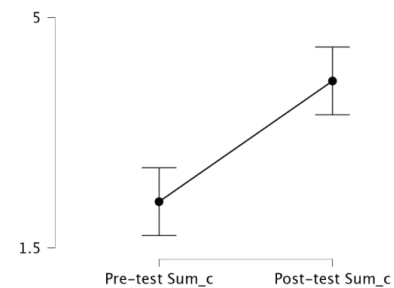
A Paired Sample T-test was used to compare the paired data for an improvement in originality. A p-value of <0.001 was yielded, which was below that of the set alpha level of 0.05. This suggests that the hypothesis was supported; participants performed better on the Paired Sample T-test in originality after using the Brick-by-Brick toolkits than before using the Brick-by-Brick toolkits.



**Figure 10:** Comparison of fluency pretest and post-test. Shows the increase in fluency from pre-test to post-test.

Comparison of the average test score in fluency pretest and post-test (before and after using the Brick-by-Brick toolkits).

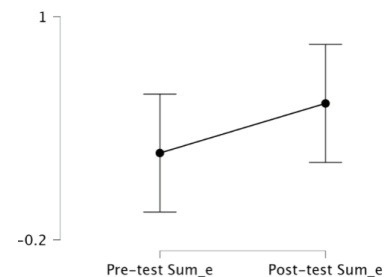
A Paired Sample T-test was used to compare the paired data for an improvement in fluency. A p-value of <0.001 was yielded, which was below that of the set alpha level of 0.05. This suggests that the hypothesis was supported; participants performed better on the Paired Sample T-test in fluency after using the Brick-by-Brick toolkits than before using the Brick-by-Brick toolkits.



**Figure 11:** Comparison of categories' scores pretest and posttest. Shows the increase in categories from pre-test to post-test.

Comparison of the average test score in categories pretest and posttest (before and after using the Brick-by-Brick toolkits).

A Paired Sample T-test was used to compare the paired data for an improvement in categories. A p-value of <0.001 was yielded, which was below that of the set alpha level of 0.05. This suggests that the hypothesis was supported; participants performed better on the Paired Sample T-test in categories after using the Brick-by-Brick toolkits than before using the Brick-by-Brick toolkits.



**Figure 12:** Comparison of elaboration scores pretest and post-test. Shows a smaller increase in elaboration from pre-test to post-test.

Comparison of the average test score in the elaboration pretest and post-test (before and after using the Brick-by-Brick toolkits).

A Paired Sample T-test was used to compare the paired data for an improvement in elaboration. A p-value of 0.117 was yielded, which was above that of the set alpha level of 0.05. This suggests that the hypothesis was not supported. This could be because the students in this study were not fluent in English, which restricted them from forming complete sentences. If the study were re-conducted and the participants had English as their first language rather than their second language, the p-value of elaboration could be expected to decrease. The lack of a statistically significant improvement in elaboration may be partly attributable to language constraints, as many participants were not fluent in written English, potentially limiting their ability to produce detailed responses despite conceptual understanding.

## ■ Discussion

This study was designed to explore the relationship between creativity, problem-solving, and Lego Brick-by-Brick toolkits. The aim was to test whether exposure to 8 Lego Brick-by-Brick toolkits over 8 days improves creativity and problem-solving in 9-12-year-old students. The objective of this study was to examine whether structured Lego-based activities would significantly enhance scores on the Alternative Uses Test (AUT). The Alternative Uses Test (AUT) directly corresponds to creativity and has been used in multiple studies. For this study, the AUT test was conducted before and after the Lego toolkits were deployed.

The setting of this study was in lower socio-economic setting schools in Mumbai, India. Students aged between 9 and 12 (3rd and 4th graders) and having no prior experience with LEGO were recruited for this study. Most young students in India do not get the opportunity to learn and grow using tools such as LEGO; therefore, this study tried to address the gaps in creative pedagogy resources for underprivileged learners.

Upon completion of the LEGO toolkit after 8 days, the findings indicated significantly improved results when compared to the pre-test. This improvement shows the effectiveness of the Brick-by-Brick Lego Toolkits and the impact they can have on students in India. The improvements varied for each student, but most students improved in Fluency, Categories, and Originality. There were major advancements in the fluidity of their thought process; the students came up with more ideas than before, and listed their thoughts down with precision. Due to this, there was more flexibility in the uses. Additionally, there were a variety of different genres of ideas in the post-test. Out of all of the kits, the "Drawing to Lego" and the "Rube Goldberg Machine" stood out as some of the most creative toolkits. The "Drawing to Lego" activity allowed the students to make their drawings come to life with Lego Bricks. This allowed them to think and imagine for themselves with no preset template. The "Rube Goldberg Machine" was really exciting for the students. They competed with each other to build the fastest and most creative way to transport a marble

from one place to another. The exposure to the toolkits had a measurable, positive effect on creativity and problem-solving.

This form of learning is holistic and hands-on, which propels a higher order of thinking. In this digital age, having a tangible experience with the Lego toolkits helped students integrate learning and play, while still conforming to the constructivist learning theory. This form of learning and testing follows Guilford's model of divergent thinking, which is measured by the Alternative Uses Test (AUT). His model requires participants to find different and creative uses for everyday objects that are unique. Moreover, the activity was done in groups of 4 or more (5 to 6)-this enhanced peer interaction, which fostered peer learning and problem solving beyond individual creativity. Working in groups brought a completely new dynamic to the way the activity was conducted; students listened to ideas from their teammates and learnt to collaborate with people they might not have worked with before. There were multiple places where some students adapted faster than others. For example, some students preferred doing functional tasks such as the "Non-Functional to Functional Objects". In contrast, others excelled in more open-ended and creative tasks such as the "Storytelling with Bricks" activity. Additionally, every student started at a different entry point in the pretest, which varied their scope to improve.

The results of this study show the major impact the Lego toolkits can have on students' creativity and problem-solving. These kits are scalable throughout India and can be a low-cost option to build creativity-based interventions in under-resourced classrooms. Furthermore, these toolkits can be integrated with government initiatives such as India's National Education Program 2020, which aims to revolutionize the Indian education system through lower and higher education.

## ■ Strengths and Limitations

This is a study of its kind, which uses students from lower socioeconomic status in India, and there has been no prior research done on the impact of Lego on this group. This experiment also has definitive pre- and post-test results from the students. Moreover, these toolkits and activities are carefully curated and designed over a long period of time. They are made to balance functional and abstract tasks while continuously improving creative skills.

Nonetheless, the sampling strategy (convenience sampling) from one school in Mumbai makes generalizability difficult. The interventions were short-term as they only lasted 8 days in total, and longer and sustained efficacy cannot be measured. Additionally, all results were based on the Alternative Uses Test (AUT); this indicates that there was only a single creativity measure. Other dimensions, like collaboration or emotional engagement, need further exploration.

One of the weaknesses of this study is that there was no control or comparison group. Consequently, post-test improvements in AUT scores might be in part due to practice effects of repeated exposure to divergent thinking tasks and not to the intervention itself. Such divergent thinking measures as the Alternative Uses Test have been reported to be susceptible to familiarity effects. Thus, the results can be regarded as the initial sign of the relationship and not a causal effect. Research

conducted in the future needs a randomized or waitlist control group and parallel-type AUT prompts to better isolate intervention effects.

The study was also based on one standardized measure of creativity, which, again, constrained convergent validity. The research was limited to the use of the AUT because it was free of license and had creative commons, and future research would consider using various instruments that have high validity to measure creativity, executive function, or problem-solving to enhance construct interpretation.

### ■ Future Research Directions

There are multiple ways of building and enhancing this research. Expansion to larger and more diverse samples, such as other socioeconomic statuses, different cities, and more rural settings, is needed. This will help in gaining more accurate results with a diverse group of communities. There is also the opportunity to conduct a long-term study over multiple months. This will help track the longevity and persistence of the gains in creativity and problem-solving. These toolkits can also be deployed at NGOs and Foundations aiming to shrink the education disparity in India. This disparity exists in most local schooling systems in the country. These organizations can also help bridge the socioeconomic status-based skill gap using playful and powerful tools such as the Lego toolkits. These kits include instructions, but are best used with a mentor or teacher for guidance. Due to this, the teachers need to go through training on how to use these kits to the best of their ability. However, these kits can also be used to highlight the importance of structured facilitation with minimal resources.

From a scalability perspective, the Brick by Brick intervention is designed to be low-cost and reusable, relying on conventional LEGO bricks and printed task cards rather than electronic components. With minimal teacher training focused on facilitation rather than technical instruction, the model is suitable for deployment in government schools and NGO-run learning environments.

### ■ Conclusion

The Lego toolkit program significantly improved the creativity and problem-solving abilities of lower socioeconomic status 9–12-year-olds. The findings and results highlight the power of structured and creative play in fostering divergent thinking and collaboration. These results offer evidence to collaborate with governments and NGOs to magnify the effect of the toolkits and integrate them within education policies and curricula in India. This study demonstrates how small, well-designed interventions can unlock the creative potential of children who might otherwise be excluded from such opportunities. A holistic education is important to train the youth to think differently and contribute to society in ways that help shape the nation.

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Vihaan Tannan is an enthusiastic 11th-grade student from Bombay International School, passionate about creativity and design, who has built over 300 LEGO sets. With a keen interest in problem-solving and innovation, they enjoy teaching and mentoring younger students, inspiring them to explore hands-on learning through building, teamwork, and imaginative thinking.