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Attainment of 21st Century Skills through Tinkering Labs

Dorothy D Souza*

St Ann's College of Education (Autonomous), Mangaluru 575001, Karnataka, India

Abstract

Renewed emphasis on STEM education, by way of use of technology and integration of STEM subjects with other disciplines, is an innovative approach to teaching-learning process. A curriculum that empowers students to develop entrepreneurship and innovation, materializing the same through Atal Innovation Mission (AIM), has been launched by the Federal Government of India. Atal Tinkering Labs are established in schools across India with the objective of cultivating 'One Million Children in India as Neoteric Innovators'. Innovative start-ups play a pivotal role in the economic development of the country and this is made possible through AIM. These labs aim to enable students to develop new skills such as problem-solving, critical thinking and collaboration and its application in the real world. The objectives of the present study are to measure the 21st century skills developed by students through tinkering labs, to assesses the correlation between tinkering labs and the academic performance of tinkers, and to evaluates the role of teachers in facilitating innovation and entrepreneurship of tinkers. The samples for the study were taken from Secondary and Higher Secondary Schools of Dakshina Kannada district of Karnataka state. The findings reveal that the tinkers developed skills such as creativity, imagination, design mindset, computational thinking, adaptive learning, and physical computing. The outcomes also show the increased growth in the academic performance of the students and the positive influence of teachers in facilitating innovation and entrepreneurship among tinkers. In conclusion, the study finds that tinkering in schools has succeeded as an activity-based pedagogy for community of learners, driving innovations for society and fulfilling the goals of Education.

Keywords: Tinkering Labs, culture of innovation, entrepreneurship, problem-solving, critical thinking and collaboration

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* Corresponding author: Dorothy D Souza. Orcid ID https://orcid.org/0000-0002-0029-4518
Email: mdorothyac@gmail.com

1. Introduction

1.1 STEM Education

The profound, pressing, and intractable challenges facing today's global society far surpass in urgency and complexity any of the previous generations and extend far beyond any individual nation's borders (Guzey, 2020). STEM education is the acronym for an interdisciplinary teaching approach that combines Science, Technology, Engineering and Mathematics. It objective is to develop critical thinking, creativity, and logical thinking skills among students. Students' learning styles and their interest are focused at in STEM education. It is an improvement upon traditional learning because it helps students integrate all disciplines into a cohesive learning paradigm based on real world application (Elaine J. Hom, 2022). STEM education is cast as pivotal in increasing productivity, prosperity and global competitiveness; as a lynchpin in addressing current and future socio-geo-political-economic challenges; as a panacea for filling shortages in workforce pipelines (Guzey, 2020).

In the context of the fast growing economies like that of India where the world becoming increasingly becoming complex, it is quintessential that the youth of India are prepared to bring knowledge and skills to solve problems, make sense of information and know how to gather and evaluate evidence to make decisions. Therefore, STEM education is considered to be crucial to meet the needs of the changing world and to prepare our students for a more STEM-based job market (Peters-Burton, 2019).

1.2 Atal Tinkering Labs

Discuss the relevant related literature, but do not feel compelled to include an exhaustive historical account. Assume that the reader is knowledgeable about the basic problem and does not require a complete accounting of its history. A scholarly description of earlier work in the introduction provides a summary of the most recent directly related work and recognizes the priority of the work of others. Citation of and specific credit to relevant earlier works are signs of scientific and scholarly responsibility and are essential for the growth of a cumulative science. In the description of relevant scholarship, also inform readers whether other aspects of this study have been reported on previously and how the current use of the evidence differs from earlier uses.

At the same time, cite and reference only works pertinent to the specific issue and not those that are of only tangential or general significance. When summarizing earlier works, avoid nonessential details; instead, emphasize pertinent findings, relevant methodological issues, and major conclusions. Refer the reader to general surveys or research syntheses of the topic if they are available. Demonstrate the logical continuity between previous and present work. Develop the problem with enough breadth and clarity to make it generally understood by as wide a professional audience as possible

(APA, 2010). Do not let the goal of brevity lead you to write a statement intelligible only to the specialist.

STEM education begins for students at their young age. The Government of India tookon its part an initiative to launch Tinkering Labs under Atal Innovation Mission (AIM) to promote STEM education in India. Atal Innovation Mission (AIM) is a flagship initiative of the Government of India, housed at the NITI Aayog, to promote innovation and entrepreneurship across the length and breadth of the country. AIM under NITI Aayog is envisaged as an umbrella innovation organization that would play an instrumental role in alignment of innovation policies between central, state and sectoral ministries, by incentivizing the promotion of an ecosystem of innovation and entrepreneurship at various levels - higher secondary schools, higher educational and research institutions (Aayog, 2019).

Through the Atal Tinkering Labs (ATL), AIM is fostering innovation at school level, wherein students get an opportunity to experience design thinking and widen their intellectual horizons in pursuit of solutions to day-to-day problems and showcase their innovations at prestigious platforms (Aayog, 2019). Innovation and entrepreneurship have become an integral part of our national mission under AIM and children as young as 12 years of age are being introduced to the world of technology innovation (Kavya, 2019).

ATL focuses on self-learning methodology, hands-on practical experience and exposure to real world situations. It equips students with 21 century skills such as creativity, imagination, design mindset, computational thinking, adaptive learning, critical thinking, digital fabrication and physical computing (Peters-Burton, 2019). While engaging in ATL activities students develop innovation but beyond nurturing innovation, students develop their personality, technological skills, life skills, soft skills and 21st century skills (Peters-Burton, 2019). ATL is encouraging students and teachers to experiment, explore and follow a self-learning path, thereby empowering them to think differently about problems and develop innovative solutions, by leveraging latest technology tools including 3D printing, Internet of Things, robotics, miniaturized electronics, space technology, drone technology, technology inspired textiles and so on (Aayog, 2019). Besides, it also creates a platform to shape an ecosystem wherein every stakeholder can contribute towards finding solutions to day-to-day problems of the society and the country (Alden, 2016).

Combining the traditional teaching methodologies with today's experiential learning will be the key towards creating a unique blended education system in India. Keeping in mind the demands of the growing economy and global growth in innovation development, the Government of India, embarked on a noble mission to create an ecosystem that nurtures futuristic skills like complex problem solving, critical thinking, adaptive learning, computational skills in children, with a vision to create one million neoteric

innovators, with the ATL initiative. The ATL initiative, across India today, is tapping on the intrinsic imaginative and problem-solving knack of children and equipping them with the required skills of the future (Aayog, 2019).

The major objectives of establishing ATL in schools are:

- To create workspaces where young minds can learn innovation skills, sculpt ideas through hands-on activities, work and learn in a flexible environment.
- To empower our youth with the 21st century skills of creativity, innovation, critical thinking, design thinking, social and cross-cultural collaboration, ethical leadership and so on.
- To help build innovative solutions for India's unique problems and thereby support India's efforts to grow as a knowledge economy (Aayog, 2019).

In tinkering labs students experiment with knowledge, try to restructure the theories learnt in the class and see the transformed results. They provide a space for tinkers for peaceful ambience for experimentation, speeds up learning, conceptualise and innovate on their own (Bansal, 2023).

STEM education has received tremendous attention from educational researchers around the world in the last decade. In the West, Maker Ed has revolutionised education system which provides a space for students to explore across multiple disciplines (Flexon, 2018).

Renewed research studies have proved the effectiveness and efficiency of ATL (Prashant Yadav, 2023) (Scheer, 2017) (Kavya, 2019) (Mane, 2022). It is also evident from research studies that STEM education supports the development of 21st Century skills (Peters-Burton, 2019) (Chhabra, 2019) (Mane, 2022). Besides, it has positive correlation with academic achievement on tinkers (Kavya, 2019). Studies have also revealed that awareness of teachers about tinkering labs needs to be increased and special efforts towards this end is essential for the success of ATL (Kavya, 2019). A study by Anvit Phatak and Vikas Mane revealed that creativity and innovation is enhanced through Tinkering Labs (Mane, 2022) and their study strongly proved that ATL has practical and creative implications upon students of secondary and higher secondary schools (Mane, 2022).

After researching on reviews and identifying the research gaps in ATL, the investigator felt the need to measure the 21st Century Skills developed through Tinkering Labs and the correlation between ATL and Academic Performance among students of Secondary and Higher Secondary Schools of Dakshina Kannada district of the Karnataka State in India. The present study aims to measure the 21st century skills developed by students through tinkering labs and attempts to assess correlation between Tinkering Labs and the Academic Performance of tinkers.

2. Method

2.0 Statement of the Problem

An assessment of the attainment of 21st Century Skills and consequent Academic Performance of students through Tinkering Labs in Secondary and Higher Secondary Schools of Dakshina Kannada.

2.1 Operational Definition

2.1.1 *Atal Innovation Mission (AIM)* is a flagship initiative of the Government of India, housed at the NITI Aayog, to promote innovation and entrepreneurship in India (Aayog, 2019).

2.1.2 *Tinkering Labs* are an initiative under Atal Innovation Mission (AIM) to promote STEM education in India (Aayog, 2019). In the present study ten schools of Dakshina Kannada with Tinkering Labs is taken into consideration.

2.1.3 *21st Century Skills* refer to the knowledge, life skills, career skills, habits and traits that are critically important to students' success in today's world, particularly as students move on to College, Workplace and Adult life (Buckle, 2022). In the present study ten skills are taken into consideration. They are as follows:

- *Critical Thinking* is that mode of thinking about any subject, content or problem in which the thinker improves the quality of his/her thinking by skilfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them (Elder, 2008).
- *Problem Solving* is the act of defining a problem, determining the cause of the problem, identifying, prioritising and selecting alternatives for a solution and implementing a solution (ReVelle, 2023).
- *Design Mindset* is a solution-focused and action-oriented approach to problem solving. It is a mindset that's focused on creating new and useful things. It involves empathy, optimism, iteration, creative confidence and experimentation (Holliday, 2023).
- *Computational Thinking* is defined as the process of identifying a clear, defined, step-by-step solution to a complex problem. It includes breaking down a problem into smaller pieces, recognising patterns and eliminating extraneous details so that the step-by-step solution can be replicated by humans or computers (Team, 2022).
- *Adaptive Learning* is the delivery of custom learning experiences that address the unique needs of an individual through just-in-time feedback, pathways and resources rather than providing a one-size-fits-all learning experience (Ben-Naim, 2022).

- *Physical Computing* is building/designing/creating/making interactive systems that use different kinds of software and hardware to sense and respond to an external stimuli – which would be a program, a problem statement, a need, an issue or simply an idea (Aayog, 2019).
- *Creativity* is defined as the tendency to generate or recognise ideas, alternatives or possibilities that may be useful in solving problems, communicating with others and entertaining ourselves and others (Franken, 1994).
- *Teamwork* is work done by a group acting together so that each member does a part that contributes to the efficiency of the whole.
- *Entrepreneurship* is the process of starting, managing and growing a business to create value or generate profit (Blasbalg, 2022).
- *Leadership* is the ability to guide and influence others to achieve a goal (Pratt, 2023).

2.1.4 *Academic Performance* is the specific level of attainment or proficiency of students as evaluated by the teachers of various subjects. In the present study academic performance is the cumulative scores obtained in their semester examination of CBSE scheme.

2.1.5 In the present study, students of Secondary and Higher Secondary School are those of class sixth to twelfth studying in Central Board of Secondary Education (CBSE).

2.1.6 *Dakshina Kannada* is the southern coastal district of Karnataka State, India.

3. Sampling procedures

The population of the present study consisted of all the students of Secondary and Higher Secondary Schools of Dakshina Kannada. Random sampling method was used in the study. Forty students from ten CBSE Schools with Tinkering Labs comprised the sample of the study.

3.1 Measures and covariates

A tool to measure 21st Century skills was constructed by the investigator. Ten skills were chosen, and it comprised of twenty five statements with four point scale.

3.2 Research design

This is a survey study and random sampling method was used to gather data on development of 21st century skills.

4. Results

4.1. Statistics and data analysis

4.1.1 The first objective was to study the 21st century skills to be developed by students working in Tinkering Labs among Secondary and Higher Secondary School students of Dakshina Kannada.

Table 1.1 shows the percentage of students opining to what extent Tinkering Labs have enabled them to develop 21st Century Skills.

Sl. No	21st Century Skills	Percentage
1.	Critical Thinking	91.2
2.	Problem Solving	91
3.	Design Mindset	94
4.	Computational Thinking	95
5.	Adaptive Learning	94
6.	Physical Computing	95
7.	Creativity	98
8.	Teamwork	90
9.	Entrepreneurship	91.7
10.	Leadership	89.5

Table 1.2: Showing the descriptive statistics of 21st Century Skills developed through Tinkering Labs.

Mean	Median	Standard Deviation		Skewness	Kurtosis
1331.6	1324	68.96	0.83	-0.37	

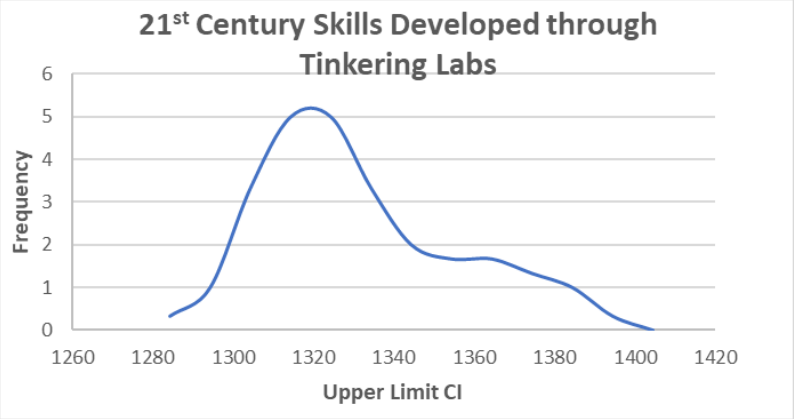

Figure 1: Showing the graph on 21st Century skills developed through Tinkering Labs.

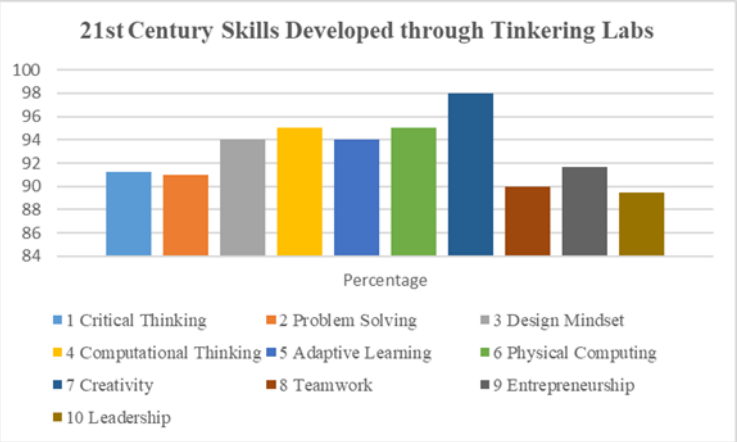

Table 1.1 shows the percentage of students opining to what extent Tinkering Labs have enabled them to develop 21st Century Skills. 98% students opined that Tinkering Lab has enabled them to develop Creativity. Another 95% students felt that Computation Thinking and Physical Computing have been developed by working in ATL. 94% of them stated that Design Mindset and Adaptive Learning is enhanced through them. 91.7% were of the opinion that the skill of Entrepreneurship is developed by working in such labs preparing them for future career. While 91.2% opined that Critical Thinking and Problem-solving skills are developed through them. 90% of them felt that ATL provide ample scope to develop teamwork and 89.5% stated that involvement in ATL has enabled them to grow in Leadership skills. This indicated that Tinkering Labs have greatly enhanced 21st Century Skills among students of Secondary and Higher Secondary Schools of Dakshina Kannada.

Table 1.2 shows the obtained Mean value 1331.6 and Median 1324. The Mean value indicates the score obtained by Secondary and Higher Secondary School Students. The Median value indicates that 50% of students lie below and above the Median value. The standard deviation score 68.96 and Skewness of 0.83 and Kurtosis of - 0.37 represents that distribution is negatively skewed that indicates the obtained score of students are not fairly symmetrical. Since the obtained Mean value is close to Median value and the Probability Curve having slight positive skewness of 0.83 and Kurtosis of - 0.37 which is negligible. It can be concluded that the scores on 21st Century Skills developed through Tinkering Labs is nearly normally distributed.

4.1.1 The second objective was to study the correlation between use of Tinkering Labs and Academic Performance of Secondary and Higher Secondary Students of Dakshina Kannada.

In order to analyse the objective, descriptive statistics like mean, median and standard deviation were used. The analysis and interpretation of the objective two was done using the Inferential Statistics. The Inferential Statistics used for analysis and interpretation of the objective two has been done using Product Movement Correlation "r".

H_1: There is a significant correlation between use of Tinkering Labs and the Academic Performance of students among Secondary and Higher Secondary School students of Dakshina Kannada.

In order to test the hypothesis, it was changed into null hypothesis.

H_0: There is no significant correlation between use of Tinkering Labs and the Academic Performance of students among Secondary and Higher Secondary School students of Dakshina Kannada.

Product Moment Correlation 'r' was used to test the statistical hypothesis. The theoretical value of 'r' was set at 0.098 for the level of significance fixed at 0.05 level with degrees of freedom 698. The details are given below in the Table 2.1

Table 2.1 Showing 'r' value representing the relationship between use of Tinkering Labs and the Academic Performance of students among Secondary and Higher Secondary School students of Dakshina Kannada.

Variable	**N**	**Mean**	**'r' Value**	**Result**
Tinkering Labs	400	25.1	0.87	Significant at 0.05 level
Academic Performance	400	49.15		

Table 2.1 shows that the value of correlation 'r' between use of Tinkering Labs and Academic Performance is 0.87 which is greater than the theoretical value 0.098 at 698 degrees of freedom. Hence, the formulated null hypothesis "there is no significant correlation between use of Tinkering Labs and Academic Performance of Secondary and Higher Secondary School students of Dakshina Kannada District" is rejected and the statistical hypothesis "there is a significant correlation between use of Tinkering Labs and Academic Performance of Secondary and Higher Secondary School students of Dakshina Kannada District" is accepted.

The table value of 'r' 0. 87 lies in the size of correlation (0.70 to 0.90) and therefore there exists a high positive correlation between use of Tinkering Labs and Academic

Performance among Secondary and Higher Secondary School Students of Dakshina Kannada District.

5. Discussion

The scores on 21st Century Skills developed through Tinkering Labs is nearly normally distributed. Use of Tinkering Lab is significantly correlated with Academic Performance among Secondary and Higher School Students of Dakshina Kannada District. Realizing the positive results of this study on the use of Tinkering Labs, the investigator recommends following implications: Access to ATL initiative should be extended to more schools and provide access to resources and technologies to students to foster creativity and entrepreneurship. Exposure to real-world problems and hands-on activities must be introduced to students to develop and enhance 21st Century Skills. Opportunities should be created in the classroom to develop learning habits of mind which encompasses qualities such as curiosity, creativity, leadership, communication, collaboration, resilience and so on. Rewards and incentives should be introduced in schools to acknowledge students' creativity and innovation in Tinkering Labs. Students should be given opportunities and exposed to engage in engineering design process and its practical usage.

6. Conclusions

The increased relevance for Science, Technology, Engineering and Mathematics (STEM) education is known to the academic world. Various methodologies have been used by governments and public agencies for imparting expertise in these areas. Government of India has introduced Atal Tinkering Labs (ATL) for the same end. This study conducted among the Secondary and Higher Secondary School students of Dakshina Kannada district indicates that that ATL is an effective way to promote innovation and entrepreneurship among students in schools. Tinkering Lab has enabled them to develop 21st Century skills preparing them to face global challenges. This study strongly supports and has evidenced the idea that tinkering-based approach proves highly beneficial to students and empowers them to develop entrepreneurship and innovation. It has revolutionised education like never before enabling them to create prototype. Besides, it has also created a culture of innovation in schools escalating their academic performance, which is key for economic development of India. Thus, Government of India's initiative to facilitate the creation of 'One Million Children as Neoteric Innovators' is highly successful.

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