iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** I **Month of publication:** January 2024

DOI: https://doi.org/10.22214/ijraset.2024.58184

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue I Jan 2024- Available at www.ijraset.com

Teaching and Learning the Fundamental of Calculus through Python-based Programming

Asifa Mulla
Master of Computer Application Mumbai University Mumbai, India

Abstract: The widespread adoption of modern Information and Communication Technology (ICT) tools in mathematics and science education is gaining momentum worldwide, especially in emerging countries with rapidly increasing digital technology penetration rates. The utilization of Python programming, with its capability to dynamically visualize abstract mathematical concepts, presents a valuable tool for instructors to elucidate calculus principles that were challenging to convey through traditional teaching methods.

This research aimed to assess the efficacy of Python-based coding in teaching the fundamentals of calculus to grade Tenth students at a higher secondary school in Mumbai India. The study employed a pre-test and post-test control group quasi-experimental design, with a total of 76 participants (34 in the experimental group and 42 in the control group). The researchers administered Python-based coding instructional units to the experimental group, while the control group received traditional lecture-based instruction. The Calculus Understanding and Teaching Effectiveness (CUTFE) questionnaire was used as both a pre-test and post-test assessment tool.

Results revealed no significant difference between the experimental and control groups in the pre-test. However, a noteworthy disparity emerged in favor of the experimental group in the post-test. Consequently, the study concluded that engaging in coding activities had a substantial impact on students' comprehension of the fundamentals of calculus. This underscores the effectiveness of Python-based coding as a pedagogical tool in enhancing students' understanding of mathematical concepts in the context of calculus education.

Keywords: Python programming, Basic of calculus, Learning outcome

I. INTRODUCTION

In the era of the fourth industrial revolution (IR 4.0), characterized by the seamless transfer of data through the Internet of Things (IoT) and cloud computing, intelligent automation fueled by artificial intelligence (AI) is significantly shaping the landscape of Information and Communication Technology (ICT) . The integration of cutting-edge technologies like IoT, Big Data, and AI into various sectors, including the economy, society, science, and education, aims to achieve rapid enhancements in productivity . At the heart of these technological advancements lies coding, the process of creating a program by composing instructions in a computer language. In essence, coding is synonymous with programming, and teaching the algorithmic principles to create a program is considered coding education

Countries such as Australia, the United States, the United Kingdom, Finland, South Korea, China, New Zealand, and Singapore recognize the paramount importance of coding education. These nations have prioritized coding by incorporating it into their educational curricula across all levels . In France, coding and mathematics are taught as interdisciplinary subjects due to their shared conceptual connections . Moreover, Finland, China, and Singapore have revamped their national standards and curricula to place a stronger emphasis on higher-order thinking, inquiry, innovation, creativity, and the seamless integration of technology into teaching and learning processes . This global emphasis on coding education reflects its pivotal role in preparing individuals for the demands of the evolving digital landscape[4]

In contrast to the traditional siloed approach to teaching calculus, the 21st-century pedagogical model embraces a more dynamic strategy, integrating powerful web 2.0 tools and adopting an interdisciplinary approach that incorporates coding. This contemporary method provides mathematics educators with a platform to creatively teach abstract and complex mathematical concepts.

Korkmaz conducted a semi-experimental study, employing a pre-test and post-test design involving 75 students to investigate the impact of Scratch and Lego Mindstorms Ev3-based programming activities on academic achievement, problem-solving skills, and logical mathematical thinking. The study demonstrated that educational programs based on Scratch had a more significant positive effect on enhancing students' logical and mathematical thinking abilities compared to the Lego Mindstorms Ev3 design and traditional teaching methods.

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Meehan (2019) adopted a mixed-method approach involving 20 fifth-grade students to explore the effects of coding integration on student engagement and academic achievement. The findings indicated a notable impact on student engagement, leading to improved perceptions of mathematics, and a significant enhancement in academic achievement.

Experimental evidence has shown that utilizing Scratch Jr. software significantly improves mathematics achievement among 6th-grade students. However, the impact on 2nd-grade students was less substantial (Moreno Leon et al., 2016). The author highlighted the need for further exploration to fully understand the effect of programming on students' mathematics achievement.

Given the limited academic discourse in Indian contexts, this study aims to fill this gap by examining the effectiveness of coding on student

II. RESEARCH METHODS

This study employed the quantitative research design in one of the higher secondary school in India. A pre-test and post-test control group quasi experimental research design was employed in this study. 76 grade tenth students who were involved in this study were divided into two groups: a control group (N=42) and an experimental group (N=34).The control group was taught using a conventional lecture method while the experimental group was taught using a python as a tool for teaching and learning fundamental of calculus.

1) *Educational Approach:* The experimental group underwent instruction using Python as a tool for teaching and comprehending calculus concepts.

```
import sympy as sym
import matplotlib.pyplot as plt
import numpy as np
from numpy import matrix
from IPython.display import display,Math
x=sym. symbols('x')
fx=(4*x*2-1)/(2*x-1)

lim_pnt=2
lim=sym.limit(fx,x,lim_pnt)
display(Math('\\lim_{x\\to %g} %s=%g' %(lim_pnt,sym.latex(fx),lim)))
fxx=sym. lambdify(x,fx)
xx=np.linspace(-5,5,100)
yy=np.linspace(-6,6,50)
plt.ylim(-1,20)
plt.plot(xx,fxx(xx))
plt.plot(yy,fxx(yy))
plt.plot(lim_pnt,lim,'ro')
plt.grid()
#plt.legend()
plt.show()
```

The concepts of the limit of a function, derivative and integral are visualized graphically using the python (see Figure 1 and 2).

$$\lim_{x\to 2} \frac{4x^2 - l}{2x - 1}$$

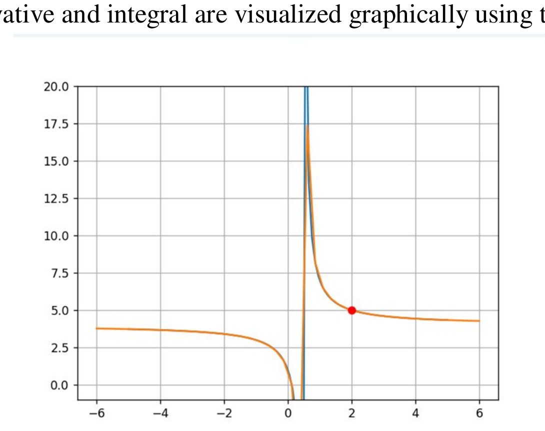


Fig 1 Graphical Visualzation of limit of function

```
import sympy as sym
from Python.display import display, Math
x=sym.symbols('x')
f=x**3
sym.integrate(f)
sym.integrate(f,(x,1,2))
p=sym.plotting.plot(f)
```

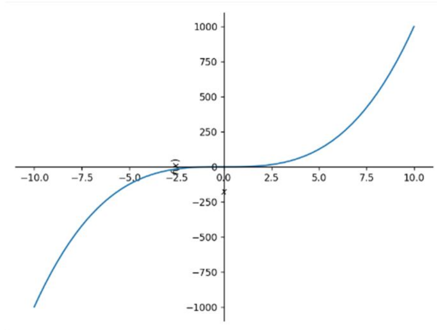


Fig. 2 Graphical Visualization of Integral

Research Group: For this research, a non-probability convenience sampling approach was employed. This method allowed the researcher the flexibility to select participants based on shared attributes or availability at a specific moment due to geographical proximity and accessibility. Given that the fundamental concepts of calculus are introduced in the eleventh grade of the Indian curriculum, the study focused on 76 twelfth-grade students from a higher secondary school in Mumbai, India.

2) *Instructional and Research Tools* : Both instructional and research tools were utilized in this study. The instructional component involved the implementation of a lesson plan developed using Python. The lesson plan was designed to integrate coding principles into the teaching of fundamental calculus concepts.
   As the primary research instrument, the Conceptual Understanding Test on the Fundamental of Calculus (CUTF) was employed to assess students' comprehension of fundamental calculus principles. The CUTF consisted of 20 questions, adapted from R.D. Sharma's Mathematics Book-I for CBSE Class XII students (R.D. Sharma, 2020). Each correct response earned one point, while null or incorrect responses received zero points. The utilization of the CUTF aimed to gauge the effectiveness of the instructional approach in enhancing students' understanding of calculus concepts
3) *Data Handling :* Prior to data collection, the study adhered to strict administrative and ethical procedures, obtaining approval from the school's action research committee. Informed consent was sought from all study participants, ensuring their understanding of the research purpose. Privacy and confidentiality measures were assured and maintained throughout the research process.
   Before the intervention, both the experimental and control groups underwent a 60-minute pretest utilizing the Conceptual Understanding Test on the Fundamental of Calculus (CUTF) questionnaire. Following the pretest, the experimental group received a 220-minute instructional unit on the fundamentals of calculus, implemented through Python-based coding. In contrast, the control group received instruction on the same calculus concepts using a conventional lecture method for an equivalent duration.
   Subsequently, both groups underwent a post-test consisting of 20 questions. The control group received traditional lecture-style instruction on the same calculus concepts for the same duration. This approach aimed to assess the impact of the Python-based instructional unit on the experimental group's conceptual understanding of calculus in comparison to the control group.
4) *Data Analysis:* The analysis of the collected data employed T-tests for comparison. To evaluate the learning outcomes related to the fundamental concepts of calculus between the experimental group taught using Python coding and the control group taught through a traditional lecture approach, the means of the pretest and posttest scores for both groups were computed.

III. RESULT

Group	Kolmogorov-Smironav Normality Test		
	Sample n)	*Kolmogorov-Smironav (Z)*	*Sig.02tailed*
Pre-text EG	42	.978	.294
Post-testEG	42	.944	.355
Pre-testCG	34	.986	.285
Post-testCG	34	1.406	.038

Note :Significant level > 0.05 =0.05= no significant, ,0.05 =significant

Test	Group	Mean	Mean difference	Sd	p
pretest	Control	9.33	2.85	4.00	0.026
	Experimental	.12.18		3.56	
Post-test	Control	10.78	.4.85	4.73	0.001
	Experimental	15.63		3.90	

Comparison of pre-test and post-test scores of Experimental and Control Group An independent sample t-test was conducted to determine the difference in scores between the experimental and control group as shown in the Table 2

The results of the independent-samples t-tests for pre-test and post-test scores between the Experimental Group (EG) and Control Group (CG) are summarized below:

1) Pre-test Scores

No significant difference was found in pre-test scores between the Experimental Group (M=12.18, SD=3.56) and Control Group (M=9.33, SD=4.00) with a t(52) = 2.88, p=0.026 (two-tailed).

The mean difference (MD) was very small (MD=0.391), and the effect size (n^2=0.006) indicated a small magnitude of differences. This suggests data homogeneity, making the groups suitable for treatment identification.

2) Post-test Scores

- A significant mean difference was observed in post-test scores between the Experimental Group (M=15.52, SD=3.9) and Control Group (M=10.78, SD=4.73) with a t(50.23) = 3.710, p=0.001 (two-tailed).
- The mean difference (MD=4.389) was substantial, and the effect size (n^2=0.91) indicated a high magnitude of differences. This suggests a statistically significant improvement in post-test scores for the Experimental Group compared to the Control Group.
- The standard deviation of the Experimental Group (SD=3.90) was lower than that of the Control Group (SD=4.73), indicating greater consistency in performance among students in the Experimental Group.

In summary, the study reveals that the application of the treatment, likely involving Python-based coding instruction, led to a statistically significant improvement in post-test scores for the Experimental Group compared to the Control Group. The smaller standard deviation in the Experimental Group suggests more consistent and higher performance among students who received the treatment.

IV. DISCUSSION AND CONCLUSION

All This study aimed to assess the effectiveness of Python coding in teaching the fundamental concepts of calculus to Grade 12students in a higher secondary school in Mumbai India. The results of the study demonstrated a significant positive impact of Python-based coding on the posttest scores of the experimental group compared to the control group, which used a conventional teaching strategy.

The higher mean score in the posttest for the experimental group indicates that Python coding had a significant effect on enhancing learning achievements in the fundamental concepts of calculus. This finding aligns with the interdisciplinary approach of teaching calculus, emphasizing the effectiveness of coding in STEM education for mathematics comprehension. The dynamic visualization of abstract concepts through coding was noted as a key factor contributing to the enhanced understanding of calculus.

The traditional lecture-based approach, characterized by passive knowledge acquisition, was found to be less effective compared to the interactive and dynamic learning facilitated by Python coding. The experimental group exhibited a more comprehensive understanding of calculus concepts, suggesting that coding instruction stimulates curiosity and active engagement in knowledge construction.

The study also highlighted the positive impact of digital tools in facilitating conceptual understanding and problem-solving skills. The lower standard deviation in the experimental group suggested more consistent and improved performance, emphasizing the effectiveness of Python-based coding instruction.

V. RECOMMENDATION

Based on the study findings, the following recommendations are proposed:

1) Integration of Coding in Mathematics Education:

Encourage the integration of coding into mathematics education to enhance conceptual understanding and problem-solving skills.

2) Interdisciplinary Approach:

Promote interdisciplinary approaches in teaching mathematics, leveraging coding as a tool to foster dynamic visualization and relational understanding of abstract concepts.

3) Professional Development for Educators:

Provide professional development opportunities for educators to enhance their skills in incorporating coding into their teaching practices.

4) Further Research:

Conduct further research to explore the long-term effects and generalizability of Python-based coding instruction in diverse educational contexts.

In conclusion, this study contributes valuable insights into the effectiveness of Python-based coding in teaching fundamental calculus concepts. The positive outcomes observed underscore the potential of coding as a pedagogical tool for improving mathematics education.

VI. ACKNOWLEDGMENTS

I express my sincere gratitude to everyone who contributed to the successful completion of this project. . I would like to thank all my professors for their unwavering support, guidance, and valuable insights throughout the research process.

Iam also thankful for the encouragement and assistance received from our peers and mentors. Their expertise and constructive feedback significantly enriched the quality of this work

Our heartfelt thanks go to my family members and friends for their understanding, patience, and encouragement during the challenging phases of this endeavor.

This acknowledgment is a testament to the collaborative efforts that have made this project possible. I'm grateful for the collective contributions that have shaped the success of this research.

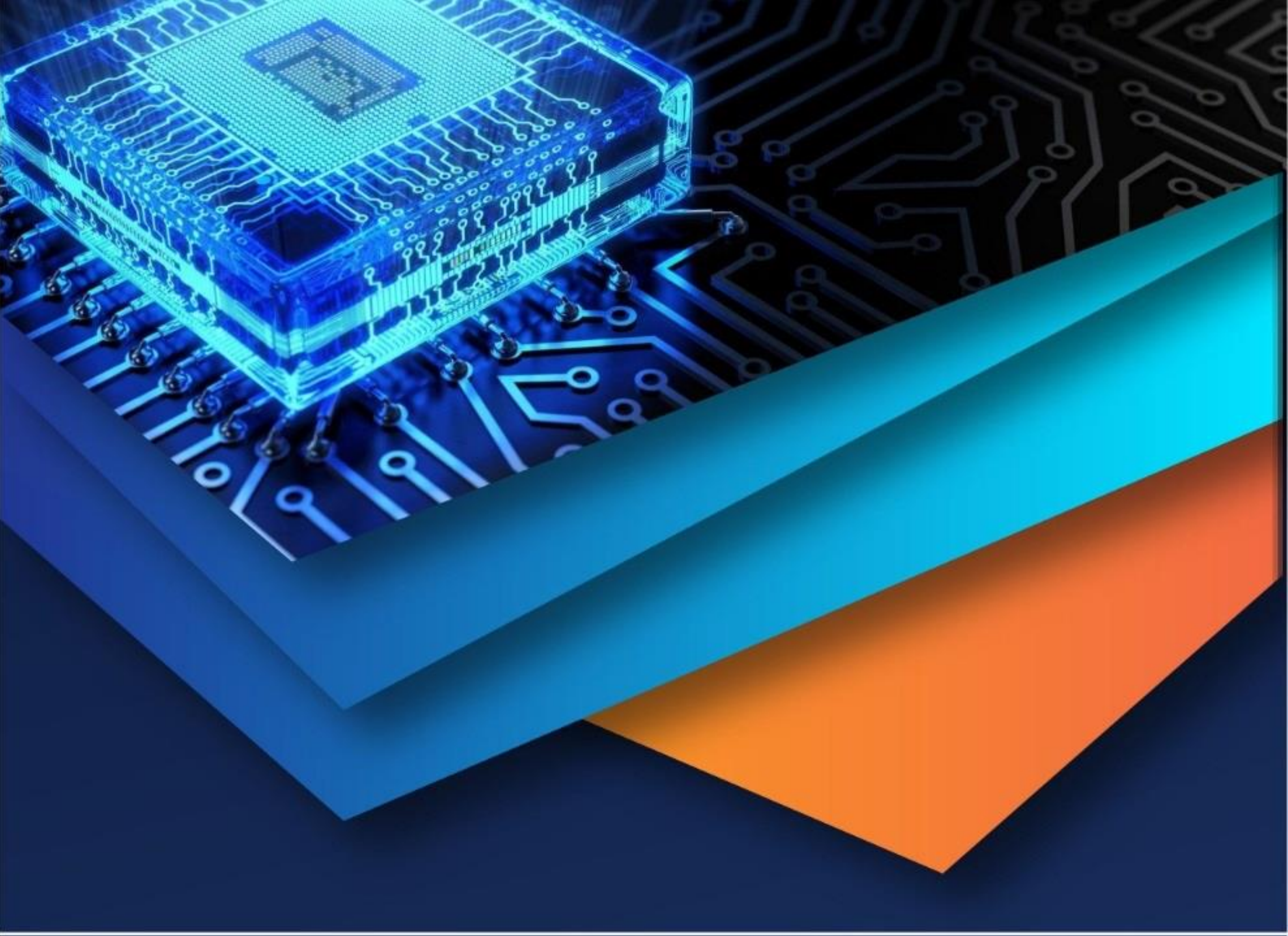
REFERENCES

[1] Bouchrika, I., Harrati, N., Wanick, V., & Wills, G. (2021). Exploring the impact of gamification on student engagement and involvement with e-learning systems. Interactive Learning Environments, 29(8), 1244-1257.

[2] Arufe Giráldez, V., Sanmiguel-Rodríguez, A., Ramos Álvarez, O., & Navarro-Patón, R. (2022). Can gamification influence the academic performance of students?. Sustainability, 14(9), 5115.

[3] Garcia, M. B., & Revano, T. F. (2021, November). Assessing the role of python programming gamified course on students' knowledge, skills performance, attitude, and self-efficacy. In 2021 IEEE 13th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM) (pp. 1-5). IEEE.

[4] Kado, K. (2022). A teaching and learning the fundamental of calculus through Python-based coding. International Journal of Didactical Studies, 3(1), 15



doi crossref
10.22214/IJRASET

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