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# Teaching and Learning C Programming and Exploring Pedagogical Strategies and the Language's Foundational Role in Software Development and Systems Programming.



**Abstract:** C is a procedural programming language, that paves the basics in why functions are used and how it is implemented. C language gives you a deeper understanding of how computers work at a lower level. C is best used in systems programming, embedded systems, and compiler design. C gives a more foundational understanding of how computers operate, while other languages focus on teaching higher-level problem-solving and programming logic. Awareness about coding is going to be a mandatory skill in our resume in the near future. As students come from different educational streams we need a more student-centric approach to make them learn. One of the main teaching challenges is the lack of tools used in imparting programming concepts. Various methodologies are encompassed to enrich C language learning and teaching.

**Keywords:** C Programming, visualization tools in C, gamification, decision system programming

## INTRODUCTION

C-programming was one of the most widely used languages for software development and for Decision Support Systems (DSS). The C programming language was created in 1972 by Dennis Ritchie at the AT&T Bell Laboratories. Though it has been more than 50 years, still C Continues to be one of the major programming languages and holds 2<sup>nd</sup> position in 2023 as per the TIOBE Programming Community index. As it is powerful, flexible, portable, and can be modularized for step-wise refinement, the popularity rises. Students face difficulties in learning the concepts of memory management. Analyzing errors in pointers, structs, and preprocessor directives make the students difficult in programming. Beginners are not well-versed with debugging and error handling in C. The syntax error messages when compiling programs make beginners discouraged in programming. Even though the beginner overcomes the syntax errors, logical reasoning and algorithm design, again is a critical problem for programming. When modern languages like Python is more easy to program then the question of why learning C arises. Learners should be given the advantage of learning C by incorporating C in robotics, IoT, or embedded systems. The integrated development environment( IDE ) influences the learning outcomes in introductory C programming courses. So beginners should be given an opportunity to work with all possible cases. The Unix kernel is written in the C programming language. It shows the efficacy of C language in system-level programming. C remains a simple and small language, translatable with simple and small compilers, and the language

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is sufficiently abstracted from machine details that program portability can be achieved[11]. To create an executable file use the Makefile which only needs to be created once, and if any new modules are added to the program then only it needs to update the Makefile. As we say C is a portable programming language, which means that code written in C can run on any machine that supports C without modifying the code.

## METHODOLOGY

### Literature Review

#### Pedagogical Approaches:

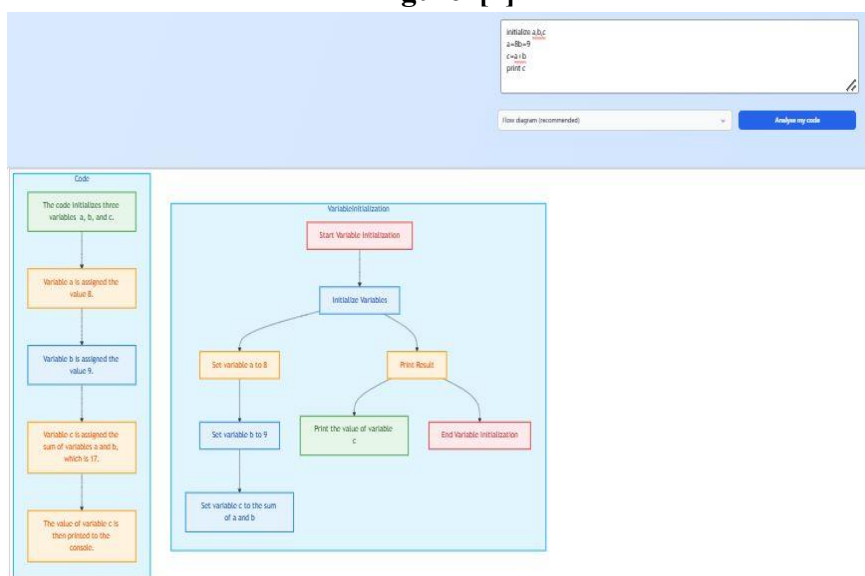
Traditional techniques for teaching C programming start with programming concepts, syntax, and problem-solving skills. Modern teaching techniques include interactive or flipped classrooms and explore project-based or problem-based learning for C programming. Visualization tools are incorporated into the classrooms.

#### Visualization Tools:

There are various visualization tools in C programming. Some of them are Debugger visualizations or flowcharts, converters of code or algorithms to flowchart, and code. Debugger visualizations or flowcharts in teaching concepts like stack, heap, and pointers can give learners a good understanding. The online site that enables visual debugging of C code step-by-step is <https://pythontutor.com/c.html#mode=edit>[1]. The debugging makes learners thoroughly understand how a C program works which in turn lets them know how to develop a logic for programming.

Learners can either use flowcharts or algorithms to begin a code design. There are ways to convert a program code or algorithm to a flowchart. One of the online codes to flowchart converter is <https://codetoflow.com/> [2]. This will help the learner to develop logic and better understand and analyze the code. Artificial intelligence can develop interactive flowcharts. Also, there is software like RAPTOR [3]to visualize the algorithm with minimal syntax. The algorithm can be converted to the flowchart in online using the site <https://www.codeconvert.ai/free-converter> [4]. Figure 1 shows code to flowchart conversion.

Figure1[2]



There may be flowcharts already available or developed by a learner which need help to generate code. Automatic code generators from flow charts are available to make coding easier. AthTek Flowchart to Code Converter [5] is a fully C code generator. The software can be downloaded and convert the flowchart to C, C++, C#, Delphi, Java, and JavaScript-type code.

Converting algorithms to code will help beginners understand how to write the correct logic to solve a problem without concentrating more on coding syntax. Also, this will help the visually impaired programmers. As beginners are unaware of how to write code, there will be many errors, so it becomes difficult for someone with no coding experience and less syntax knowledge to write any code. The algorithm to code converter will be helpful for beginners to convert the given input algorithm to its corresponding code [6]. Figure 2 shows the conversion of the algorithm to code.

**Figure 2**

<pre> 1 initialize a,b,c 2 a=9 3 b=8 4 c=a+b 5 print c </pre>	<pre> 1 #include &lt;stdio.h&gt; 2 3 int main() { 4     int a, b, c; 5     a = 9; 6     b = 8; 7     c = a + b; 8     printf("%d\n", c); 9     return 0; 10 } 11 </pre>
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Teachers can often provide students with some reflective mode of teaching which comprises purposeful training, combined with the content of learning for sustained development so that students slowly master in common programming methods[7].

#### GAMIFICATION:

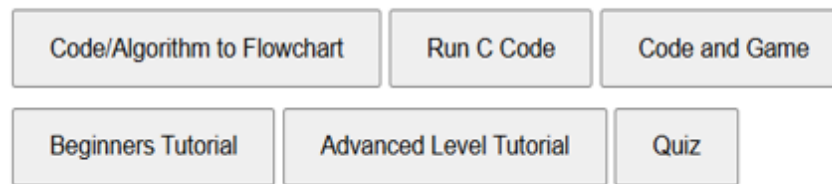
Gamification is adding game elements into nongame programming environments to increase participation or engagement. The impact of gamified learning tools will improve the logical skills of the learner in the program. One of the educational platforms used to learn coding through gamification is CodinGame[8]. While the majority of gamification platforms use badges, achievements, and points, CodinGame uses actual games to help in the learning process[9]. It Provides programming concepts at various levels and gives assignments and quizzes. Students' behavior is tracked and analyzed at each level. Gamification relatively solves the student's lack of interest and provides motivation and engagement in learning[10]. C-Quest is a gamified Android application that offers interactive simulations, syntax tutorials, practical tasks, engaging challenges, and performance assessments tailored for mastering C programming. Include quizzes to analyze the level of the learner.

If we study C program first then any modern programming language can be learned easily. For example, the method of writing the block of statements in C will help the learner how it is done in Python and why [12]. Bridging C with other programming languages like Python or Java enables one to leverage the strengths of each language in a single application. This approach is often used in performance-critical applications or when integrating existing C libraries into higher-level languages for code reuse.

The working model in Figure 3 of encompassing available tools in the proposed pedagogy is utilized in online classrooms for a better understanding of Programming for learners.

Figure 3

# C Programming Pedagogy



## CONCLUSION

To teach visually impaired students we can use voice commands to invoke a terminal and execute compilation commands like `gcc hello.c -o hello`. Application of C programming skills can be used in higher-level like operating systems or compiler design for better career opportunities. By using innovative teaching methodologies skills in C coding can be improved. Online C programming courses can be blended with regular classes to evaluate engagement and performance. Incorporated algorithm or code to flowchart, online c compiler, and gamification for C coding in online classrooms for better C programming education. Real-world programming applications should be done in practice to connect abstract ideas in effective teaching strategies.

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