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## Anchored instruction ITS: a novel approach to make learning programming interesting and effective

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# Anchored instruction ITS: a novel approach to make learning programming interesting and effective

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**Abstract.** Learning programming is known to be troublesome to the students in the computer science department. The problem is originated in the students' inability to understand the logic in developing the program. Many teachers advise the students to practice writing the program to improve the students' skill. However, many students do not enthusiastically follow this advice due to the unattractive activity in writing the program as well as the lack of help when they have problems in writing the program. In this research, we proposed a system that increases the attractiveness of the program development activity and is able to provide help when the students have problems in it. These goals were performed by integrating an anchored instruction in an Intelligent Tutoring System (ITS). The attractiveness of the anchored instruction and the effectiveness of the Intelligent Tutoring System were analysed using a pre- and post-test, and a survey. From the tests and the survey, we found that the anchored instruction can increase the students' interest in practicing programming; the Intelligent Tutoring System could help the students in writing the program and improve their knowledge in programming (24.67% improvement). The research showed that anchored instruction Intelligent Tutoring System can be used as an alternative approach to make learning programming interesting and effective.

## 1. Introduction

Teaching and learning programming are known to be hard [1, 2, 3]. In order to have a good knowledge in programming, students should practice writing computer programs. Unfortunately, many students find that writing the program for the given exercises are not interesting and too difficult. Students often have problems in understanding the logic of the program to make. As a result, many students do not spend enough time and effort to practice programming.

Some works have been performed to make learning programming becomes interesting. Some of the works incorporated games in the learning and some others involved the usage of modern technology such as mobile devices. The incorporation of games in learning programming can be in the form of creating games [4] or playing games to understand computer programming topics [5].

In this research, we investigated another approach of making learning programming becomes interesting using anchored instruction. Anchored instruction has been used to motivate students and make learning become more interesting by emphasizing generative learning anchored in meaningful contexts [6,7]. In anchored instruction, the learning activities are designed around a story or situation



that includes a problem. The students are expected to use their knowledge and skills to solve a certain problem posed in the story.

Anchored instruction has successfully been used to increase the students' motivation in learning mathematics, science, and statistics, but it has never been tried in the programming domain. It is interesting to know if anchored instruction can also be used to increase students' interest in learning programming.

The usage of anchored instruction in learning programming can be optimized if the system can also help the students to understand the logic of the program to be developed. Providing an individual tutor that can help students in their specific problem can make learning becomes more effective [8]. However, it will be resourced impractical to provide as many tutors as the number of students. One possible solution is to create a system that can provide specific help to the students' problems as if a human tutor will do. This system is called an Intelligent Tutoring System.

An Intelligent Tutoring System (ITS) is a computer program that can tailor its assistance and teaching to the student current knowledge [9]. Some ITSs have been built in the programming domain, for example: PHP ITS [10], J-LATTE [11], and JITS [12]. Unfortunately, there was no evidence that these ITSs were designed to make learning programming interesting.

An ITS that can assist the student individually and make the learning process becomes interesting is a good candidate to change the student perception that learning programming is hard and dull. This paper proposed a novel approach to make learning programming becoming interesting and effective by incorporating anchored instruction in an Intelligent Tutoring System. The pedagogy that we used in our Intelligent Tutoring System required the students to write programs to learn programming.

## **2. Previous work on anchored instruction and Intelligent Tutoring System (ITS)**

Anchored instruction is an instructional framework of which the instruction is anchored or situated in the context of meaningful problem-solving context to overcome the inert knowledge problem [6]. It is the context that makes learning becomes interesting because it reflects the true nature of problems in the real world.

In anchored instruction, the learning activities are designed around a story or situation that includes a problem or issue. Some works that utilized the concept of anchored instruction can be seen in Prado and Gravoso [6], and also in Kumar [7]. The usage of anchored instruction in this research increased the students' interest to the subjects, decreased their tensions in learning, and improved their skill in problem solving

Intelligent Tutoring System works like a human tutor. The system can predict the student's current knowledge and use the information to provide the most suitable instruction or exercise. The ITS can also interpret the student responses and offer hints to help the student to understand the material or to complete the given exercise. Therefore, the ITS can be considered as a private computer-based tutor.

Some ITSs, such as JITS, J-LATTE, or PHP-ITS have been built in the programming domain [10-12]. JITS were created to help students in their first programming course to learn programming in Java. JITS was designed to recognize any small Java program and offer intelligent feedback when there is no authored solution available [12]. As a result, JITS can only produce a syntax error correction or assistance system. These features may not give additional assistance to the students because these features are already provided in many compilers.

Other ITSs, such as J-LATTE and PHP ITS provide assistance to the students when they have problems in the syntax and logical error. Assisting students to understand the logic of the program is important because many students have problems in understanding the logic of the program or how to fix a logical error in the program development. J-LATTE and PHP ITS start the tutoring process by giving some programming questions to the students. After selecting a certain question, the students can write the program on the developed application. Some buttons are provided to let the students choose some actions, such as submitting the program or requesting help.

PHP-ITS was created to help students learn PHP. PHP-ITS used predicates as a set of constraints to check if the students' programs had achieved the expected goal or not. The goal itself was divided into several sub-goals. These sub-goals were used to give specific feedback to the students. Although JITS, J-LATTE, and PHP ITS were created to help the students in learning programming, they were not

designed to make the learning process become interesting. The learning process in the ITSs were similar to the one in the classroom, which some students considered uninteresting. Many exercises were presented without context and were not designed to inspire the students of their possible use to solve real world problems.

### 3. Anchored instruction ITS

Having a potential to make learning become interesting, anchored instruction can be used as the pedagogy in the developed Intelligent Tutoring System, named CSharpTutor. Some aspects that make learning becomes effective were also included in the design of CSharpTutor. The anchored learning in CSharpTutor was implemented using a role playing.

In the role playing, the student has a role as a programmer who works in a company. When the student starts CSharpTutor in Visual Studio, a greeting from a virtual Head of Development is displayed. The Head of Development will ask the student to show his capability in writing programs for some given cases to be accepted or to get a better position in the company.

The program for the case given by the Head of Development can be written by the student in Visual Studio directly. Unlike any other existing ITS, CSharpTutor was developed and integrated with Visual Studio, the development environment that is used by the targeted students. This integration enables CSharpTutor to read the student code in Visual Studio directly and gives advice about how to create the program for the given case.

As an ITS, CSharpTutor tries to understand the student program and provides feedback upon the student request to the logical error in the program. Understanding the logic of the student program was performed using first order logic. The solution of the case was represented into goal and sub goals in the first order logic representation. The student program was parsed and translated to predicate logics. The predicate logics were checked if they can satisfy the goal or sub goals. This information was used to give feedback to the student or to advance the student to the next case.

The following is the example of the goal that must be satisfied by the student program to convert the temperature value from Celsius to Fahrenheit:

```
goal ← var(CelsID, celsius),
       val(CelsID, Cels),
       var(FahrID, fahr),
       val(FahrID, valFahr),
       eq(ValFahr, 9.0/5.0 * Cels + 32),
       print(FahrID)
```

After completing a program for a case given by the Head of the Development, the student can submit his work to the Head of the Development, and the Head of the Development will assign another case to be solved by the student. The submission can be performed through CSharpTutor. After several correct program submissions, the Head of the Development will promote the student to a higher position in the company. With this promotion, the student will be given a new case that needs more advance programming skill.

There are three levels that exist in CSharpTutor. The topics assigned for each level are:

- Level 1: variables, assignment, and input output statements
- Level 2: simple condition
- Level 3: nested condition, repetition, and one-dimensional array

We also named the level with a certain position in IT company, such as Junior Programmer, Senior Programmer, and Analyst Programmer. The story about being a programmer and to achieve a higher position in the company were chosen because many students enrol in the computer science department with an expectation to be able to work in a programming-related working area when they graduate one day. Aligning the role playing with the student expectation can increase the student interest and motivation in learning programming.

CSharpTutor contains 16 cases that can be completed by the student. However, the student may not be asked to complete all cases in CSharpTutor. Based on the student model that was developed when

the student submitted his/her programs, CSharpTutor can suggest the most suitable tasks for the student current knowledge. For example, if the student makes unnecessary mistake in writing the program for a case in certain level or ask too much help from CSharpTutor then CSharpTutor will use this information to update the student model. The student model is also updated based on the student submitted program. Using this student model, CSharpTutor will select the next case that should be given to the student.

The topics are represented as variables in Bayesian Network along with other variables created from the cases' sub-goals. The Bayesian Network is used to estimate the probability of the student knowledge of a certain topic. Using Bayesian Network, CSharpTutor can update the belief for the variables in the network based on the new evidence. For example, if the evidence shows that the student can write the program for a certain case correctly, we can use Bayesian Network to increase our belief that the student knows the topics that are related to that case.

All cases in CSharpTutor are connected to a certain context. Having an exercise in a context encourages and motivates students to complete the exercise because they can see the "real" application of the program that they made [13]. It is necessary to change the real cases to simpler version to make them on par to the student knowledge. CSharpTutor does not have any out-of-context tasks that commonly be seen in many programming books such as "swap the values in two variables" or "find the average of  $n$  numbers", etc.

The assistance in CSharpTutor is designed to be adaptive and multilevel. In this case, CSharpTutor checks the condition of the student program using code analyser [14] to determine the sub goals that cannot be accomplished by the students and display the appropriate assistance to the student. The assistance is displayed in multilevel. When the student has the problem for the first time, a general level assistance will be displayed. A more detail level of assistance will be given if the student keeps having problems with the same issue. CSharpTutor also provides a minimal feedback by just responding "yes/no" when the student asks if his/her program is correct or not. This feature is provided to encourage the student to find the solution him/herself before he/she asks the detail help from CSharpTutor. All of this helps can be obtained by pressing a certain button in CSharpTutor.

#### **4. Methods used to measure the effectiveness and the interestingness of anchored instruction ITS**

In evaluating the effectiveness and the interestingness of anchored instruction ITS, 36 students in Programming class voluntarily tried CSharpTutor. Before the students started CSharpTutor, they had to answer 20 multiple choice programming questions that were used a pre-test. These questions were presented again in random order as a post-test. In addition to these data, CSharpTutor also recorded the submitted students' programs, the information about which tasks that were completed, the date and time when the students wrote the program, the length of time needed to complete a program (omitting the idle time when the students did nothing in the development environment), and the number of help requested by the students. All of these data were used to measure the effectiveness of CSharpTutor. On the other hand, the interestingness of the anchored instruction ITS was measured through a questionnaire. This questionnaire had to be filled by the students after they completed the post-test.

### **5. Result and discussion**

#### *5.1. The effectiveness of CSharpTutor in helping student learn programming*

The effectiveness of CSharpTutor in helping the students learn programming was evaluated by analysing the students pre- and post-tests. The students' average score in pre-test was 64.17 and the students' average score in post-test increased to 80 (24.67% improvement). A one-tailed paired t-test with a 95% confidence interval was used to check if the average score in post-test was significantly better than the average score in pre-test (see Table 1). The null hypothesis for this test was: the students' scores in post-test were not higher than the students' scores in pre-test. The p-value of one tailed paired t-test could be found by dividing the p-value of two-tailed paired t-test by 2, that was 0.00007. This p-value showed a strong evidence that we could reject the null hypothesis. This means that the students' average score in post-test was significantly higher than the students' average score in pre-test.

This finding shows that anchored instruction ITS can be used in an ill-defined domain such as programming and produces as effective result as the one in the well-defined domain [6,7]. The

integration of anchored instruction to an ITS is necessary to check the correctness of the student program and use it to advance the story in the anchored instruction. The ITS is also needed to provide assistance to the student in writing the program.

**Table 1.** Paired t-test of the students' post-test and pre-test.

	Mean	Std. Dev.	Std. Error Mean	95% confidence interval of the difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pair 1. Post Test – Pre Test	15.83%	18.80%	3.13%	9.47%	22.20%	5.05	35	0.000015

We also measured the contribution of CSharpTutor in supporting students to learn programming. Some statements in a questionnaire that we used to measure this aspect were:

- CSharpTutor assistance is helpful
- The number of tasks given in CSharpTutor is ideal
- Overall, CSharpTutor helps the students in learning programming

Most students responded positively to the statements above. 67% of the students agreed or strongly agreed that CSharpTutor assistance was helpful. The number of tasks in CSharpTutor was considered ideal or almost ideal by 77% students. Because of the adaptive tasks used in CSharpTutor, the students who can do well in the pre-test and can submit correct codes got fewer tasks to be completed than the students who did the opposite. This positive feedback showed that the students were satisfied with the usage of adaptive number of tasks given in CSharpTutor. When the students were asked about the overall performance of CSharpTutor in helping them learn programming, 92% of the students agreed or strongly agreed that CSharpTutor could help them learn programming.

### 5.2. The interestingness of anchored instruction ITS

We also used questionnaires to measure the interestingness of anchored instruction ITS. We used a five level Likert scale that ranges from strongly disagree, agree, neutral, agree, and strongly agree. The following statements were used in the questionnaire:

- The role playing in CSharpTutor is good
- The approach of giving a higher level goal in writing the program is good
- The approach to learn programming by writing program is good
- The approach of giving the students a chance to develop answers themselves by providing multilevel help is good

From the questionnaire, 75% of the students agreed or strongly agreed that the role-playing approach was good. 25% of the students gave a neutral opinion, and none of them disagreed or strongly disagreed. The students also gave positive responds when they were asked about the approach of giving higher level goal to be achieved when they wrote a program. Writing a correct program became an intermediate goal to achieve higher level goal that was being promoted to a better position in the company. 89% of the students agreed or strongly agreed with this approach. Again, none of the students disagreed or strongly disagreed.

All students (100%) also agreed or strongly agreed that the best way to learn programming was by writing programs. An interesting approach such as the one used in CSharpTutor could encourage the students to practice programming. Most of the students (97%) also agreed or strongly agreed that the students should develop the answers themselves before they got help from CSharpTutor. This was performed in CSharpTutor through a multilevel and a “yes/no” help.

## 6. Conclusion and further work

The findings from this research indicated that anchored instruction ITS can effectively help student learn programming. In addition, learning programming in anchored instruction ITS makes the process of learning itself become more interesting. The usage of the ITS becomes the key point in making the success of the system. The ITS guides the students to understand the logic of the program to be written.

Other educational related factors also give contributions in the success story of helping the student understands programming. These factors are minimizing the cognitive overload by integrating CSharpTutor to the development environment, the usage of case based exercises that provide an idea of the real world application of the program, the adaptive feedback to help the students to understand the logic of the program, and the multilevel feedback to give the students a chance to think the solution themselves.

For further work, the story on the anchored learning can be changed to another story that is still in the students' interest, for example to the one that includes modern technology or science fiction. The ITS can be extended to another development environment or to another mode in Visual Studio such as to Windows Forms or to Windows Presentation Foundation (WPF) application. The topics in the ITS can also be added to a more advanced topic such as method and class. A more extensive evaluation can be conducted by increasing the number of participants and the usage of cohort to compare the result.

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## Preface

Welcome Remarks,  
Chair of the Steering Committee

It is a great pleasure to welcome all of you to Bali and to the International Conference on Informatics, Technology, and Engineering 2019 (InCITE 2019) held by the Faculty of Engineering, University of Surabaya (UBAYA) in collaboration with The University of Adelaide, Australia and Sirindhorn International Institute of Technology (Thammasat University), Thailand. The first InCITE has been successfully held in Bali, Indonesia in 2017. We are very delighted to host the second InCITE here in Bali, Indonesia again.

There are more than 75 presentations in this conference. We welcome leading experts not only from Indonesia, but also from different parts of the world. The experts will share the knowledge and experiences in the fields of informatics, technology, science, and engineering. The main theme of this conference is **Enhancing Engineering Innovation Towards A Greener Future** in response to several world challenges including sustainable development, global convergence of information and communications technologies, climate change and global warming as well as the depletion of unrenewable natural resources. We hope this conference will provide you a good opportunity to get to know each other better and consolidate bonds of friendship and mutual trust.

We would like to express our sincere gratitude to the Keynote and Plenary speakers, International Scientific Committee, Steering Committee, and Organising Committee for their huge efforts to make this conference successful.

Thank you all for your support and attendance at InCITE 2019. Please enjoy the conference and Bali !

Asst. Prof. Djuwari, Ph.D.





## Preface

Welcome Remarks,  
Chair of The Organizing Committee

Welcome to Bali, Indonesia to all delegates and presenters. It is my pleasure and privilege to welcome all of you to the 2<sup>nd</sup> (second) International Conference on Informatics, Technology, and Engineering 2019 (InCITE 2019) held by the Faculty of Engineering, University of Surabaya (UBAYA) in collaboration with The University of Adelaide, Australia and Sirindhorn International Institute of Technology (Thammasat University), Thailand.

InCITE 2019 has received more than 75 papers to be presented in this conference. All papers represent four following parallel clusters: Green Design and Innovation, Green Manufacturing and Green Processes, Power System and Green Energy Management, and The Role of IT in Innovation Enhancement. Each cluster supports the main theme of the conference, which is **Enhancing Engineering Innovation Towards A Greener Future**. The engineering innovation is the key to increase our awareness in maintaining the sustainable growth and development in the world.

The Organising Committee of InCITE 2019 would like to express our sincere gratitude for the tremendous supports and contributions from many parties. The supports from The Faculty of Engineering of UBAYA, keynote and plenary speakers, our International Scientific Committee, the Steering and Organising Committees are really acknowledged.

The last but not the least, thank you for your supports, enjoy the conference and we hope through this meeting all of you can extend your networks and collaborations.

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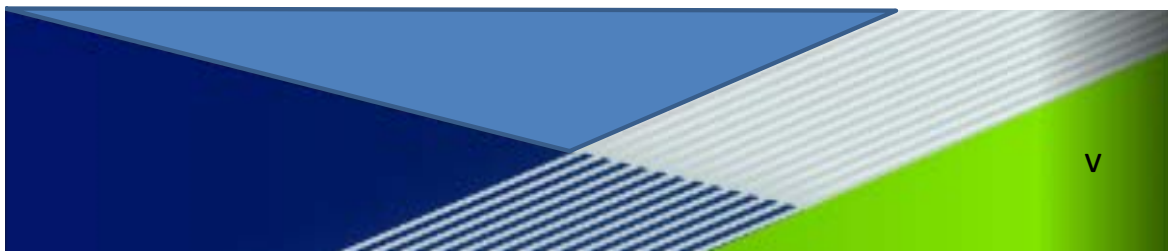
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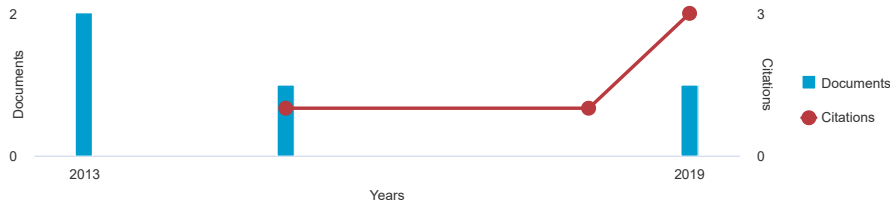
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