Utilization Visualgo.net as a Data Structure Learning Media based on CDIO

Aji Prasetya Wibawa¹*, Felix Andika Dwiyanto¹, Triyanna Widiyaningtyias ¹, I Made Wirawan ¹, Wahyu Sakti Gunawan Iriyanto ¹, Ansari S. Ahmar²,³

¹Department of Electrical Engineering, Universitas Negeri Malang, Malang, Indonesia
²Department of Statistics, Universitas Negeri Makassar, Makassar, Indonesia
³AHMAR Institute, Makassar, Indonesia

*aji.prasetya.ft@um.ac.id

Abstract. On the data structure course, there are some problems appear during the learning process. The main problem that occurs is lack of comprehension data structure in theory related to implementation practical teaching. In other case, the classic teaching method considered as one of problem caused. The comparison between classic teaching method and CDIO approach are the learning result with CDIO are better because this model aims at ability to practice and innovate based on learning theory and problem which may be faced in real life. This article will discuss the general conditions and problems of classical data structure learning and completion efforts using visualgo.net as a learning media.

1. Introduction
Data structure is one of basic component in computer science[1]. In programming, data structure is a way to store and represents data in computer to be used more efficient[2]. In the lectures, data structure is a course consisting of a theory that aims to train abstract thinking skills and practical teaching that trains the ability to innovate and solve a problem using computer technology.

In fact, the data structure course has some problems in its implementation[3]. The main problem that occurs is a abstract concept comprehension of data structure that are studied by student in course. They have difficulty in implementing and solving problem into programming. The possible cause of the problem is the implementation of classical teaching. Students tend to only practice programming to the extent of practice and problems that exist in teaching materials. This causes them to lack innovation in terms of problem solving. In addition, the ability to teamwork in problem solving is less evident in learning as they work independently.

2. Classical Teaching
Generally, the data structure course still use the classical method. In theory, students learn about concepts of data structure. In practical course they have to make solutions to the problem associated with data structure in a program.

The problem is there are still many students who do not understand the concept correctly. So they have difficulties in making the program. The possible cause of this problem is there are no learning media to visualize the abstract concept to make it easier for students to understand [4].
In classical teaching, the visualization of data structure is only described and presented on the whiteboard\[5\]. In this way, students tend to be less interested and passive in the class. They just listen and write the explanations described and written in the whiteboard. In addition, when they are given the opportunity to ask, still a few of them ask because they still do not understand what will be asked. The results are still many of those who have not clearly understand the concept of data structures, evidenced by answers that are still less precise of a data structure problem.

Moreover, another problem that is contained in this classical teaching is utilization of teaching materials that have been used for long time without any change from the content of the material and exercise\[6\]. So, the courses are too patterned and students can also get the program they needed from their seniors. They no need to create the programs to solve the problems that exist in the teaching materials.

Some points of problems that occurs from the classical teaching are:

- Lack of understanding represents abstract data into program
- Lack of student activity during learning
- The utilization of teaching materials with less change and innovation.

3. CDIO

In the current era of globalization, competition for professional workers is very strict especially on engineering area. Therefore, the current engineering education should be able to produce a prospective engineer who suits with company demand\[7\]. The engineer talents not only has good grades in their school, but also has professional knowledge, practical engineering competence, ability to solve problems, and ability to work together in team.

The CDIO method is an approach for educating students as well-rounded engineers who understand how to Conceive, Design, Implement, and Operate in a team based environment\[8], [9\]. This approach stresses the fundamental of knowledge and skill at the engineering education. The system goal is to develop an effective and exciting learning for student \[7\], [10\].

Data structure is one of important thing on computer science. It is one of basic ability in software engineer major \[11\]. On the data structure course, student learned how to process and store data effectively in the computer\[12\]. With the complex characteristic of data structure, it should be implemented with the right learning method. With the adequate media visualization during learning using a visualgo.net evidently the learning outcome is not yet reached. Even visually they already understand concept of data structure, but there are still problem during practical teaching \[13\]:

- Lack of innovation at problem solving
  
  On the data structure course, student only provided with limited learning resources (theory, exercises, and case study). So, in the problem solving process they tend to work on similar problem and solution.

- Programming skill cannot be improved
  
  The impact from lack of innovation during the learning cause many of students not serious while working and just duplicate their friend’s work. So their programming skill cannot be improved.

- Not cultivate team work process in problem solving
  
  The individual working cause student can’t practice communication ability and cooperation ability. Because, the team work process are one of necessary thing to problem solving in data structure course.

From description above, CDIO approach need to implement because it has right characteristic to solve the problem. CDIO approach has 4 main component (Conceive, Design, Implementation, Operation). All four components will be divided and implemented by these step\[14], [15\]:

| Table 1. CDIO Approach Step by step |
### Phase  Step by step

**Conceive**

1. Read and understand the problem  
2. Identifying pre and post condition from the problem  
3. Choose the possible solutions of the problem

**Design**

4. Analyze details of the problem  
5. Choose the best solution of the problem

**Implementation**

6. Make the coding program  
7. Program testing

**Operation**

8. Presenting and testing with a little change at program from instructor and other student to testing if program running well and effectively or not.

- **Conceive**  
  In this phase, student need to read and understanding the tasks and problem given. They can find reference and observation from any source. Then, they have to identifying pre and post condition of the problem. So, they can choose the possible solutions of the problem.

- **Design**  
  In this phase, they have to re-analyze details of the problem like a data type, algorithm, and data structure used of the program. Then, they choose the best solution to solve the problem.

- **Implement**  
  After the solution selected, they started to make a manual coding with algorithm or pseudocode. Then, they can make a program and ready to test to their teammate.

- **Operate**  
  In the last phase, they will presenting and testing the program they made in front of class. They have to explain the program to all student and the instructor. Then, the instructor and other students can give a suggestion or make a little change of program to test the program running well and there is no error or a bug.

4. **Utilization Of Visualgo.Net For Learning**  

Visualgo.net is a web-based learning media which has a function to visualize many kind of algorithm an data structure[5], [16], [17]. On the learning process, it used for learn data structure more interesting with a visualization[18]. Some features of visualgo.net are:

- It does not require any additional to use  
- Display a visualization of many kind of data structure with friendly user interface.  
- Describe concept and characteristic of algorithm and data structure with data input from user dynamically.
It also has an online quiz with grading system to motivate students on learning of data structure.

Figure 1 is a home screen of visualgo.net. The home screen display a main menu and many variations option of algorithm and data structure. Students can choose and access the algorithm and data structure to learn more interesting.

![Visualgo.net Home Screen](image)

**Figure 1.** Visualgo.net Home Screen

On a practical teaching based on CDIO, visualgo.net used in conceive (C) phase. In this phase visualgo.net used as visualization tool while they working to solve problem with a specific data structure. For example, there are a case study as follow:

- On the stuffs storage there are many stuffs had to record on the item list. The income stuff will be sequentially added on the list. The selected item will be deleted on the list. Of the case study, make a program which functionally save the item list. Then, from the current list program can delete item form the first of the list, last of the list, or in the middle of the list. Used a linked list concept to make the solution.
Figure 2. Linked List Data Structure Visualization

Figure 2 is a visualization of a linked list data structure. The visualization show a correspond concept of the case study. With an information like a head as a first of the list, tail as a last of the list, and temp as middle of the list. With a visualization student can imagine adding or deleting item process from the list. Also, there are pseudocode algorithm on the bottom right display will show the process while modification or manipulation the element of linked list.

Figure 3. Some Features of Visualgo.net
Figure 3 is a preview of some features on visualgo.net. While you access an algorithm and data structure visualization on it you can use a features to make a visualization depends on your necessary. For example on figure 3 is a visualization of linked list data structure. On preview page you can found some features in the left bottom page. Some of the features are create, search, insert and remove. In create options you can make a value of linked list element, you can make it random, random sorted, or an element input by a user. In search option you can search an element in your linked list and the visualization will run a process and algorithm of a searching in linked list. In insert option you can insert an element to your current list, you can insert on first list (as a head), on last list (as a tail), or a specify place (between two current elements). And in the last option you can remove an element of your linked list.

With some features of visualgo.net which describe above, it will facilitate students while learning data structure. They can more easily to explore and learn how algorithm and process of data structure works. So, they can be more understand about the abstract concept of data structure. And they can implement the concept of data structure to a program they have to make as a solution of a problem or a case study given.

During the learning, students has given some questions about the data structure practical teaching and media used in learning (visualgo.net). From the observation conducted during the learning, student has answer some of questionnaire about the data structure practical teaching. There are samples of their answer describe on table 2:

| Student's name | Response |
|----------------|----------|
| A. C.          | Pro’s : Learning method, learning media, lecture  
                 Con’s : - |
| M. R.          | Pro’s : Learning method, learning media  
                 Con’s : programming language too difficult |
| M. D.          | Pro’s : Learning method, learning media  
                 Con’s : - |
| W. L.          | Pro’s : Learning media  
                 Con’s : - |
| P. Y.          | Pro’s : Learning method, learning media  
                 Con’s : - |

From the student’s response about the data structure practical teaching, mostly of them give an opinion that learning method and learning media used on course is helpful and more interesting.

The observation result, around 65% students helped with application of visualgo.net. Learning become more interesting because visualization of data structure which has some of information and algorithm explanation. The students can also input the data which are desired to be process on the concept of data structure. The students feel more understand with an assistance visualization media visualgo.net.
5. Conclusion
The data structure course with a classical teaching causes a passive learning and make it difficult for students to understand the lesson. To improve an interest of learning, then need a change of learning method. One of the transformation is a utilization learning media which make the students more interesting. Visualgo.net as a media used on the data structure course can improve interest of learning because it used visualization and algorithm explanation. Visualgo.net can be a media to understand abstract concept of data structure. So, the students can be more easier while make a solution in programming.

The utilization of visualgo.net is a part of Conceive(C) phase in CDIO approach and already success to improve understanding and interest of data structure. However, only using a visualization is less than enough for the data structure. The CDIO approach need to implement to improve innovation ability and creativity. So, if the other phase of CDIO approach (Design, Implementation, and Operation) can be implemented it will make better learning outcome that more appropriate with the learning objectives.

References
[1] Beynon-Davies P, 2016 Instituting facts: Data structures and institutional order Inf. Organ. 26 p. 28–44.
[2] Lawrence R, 2004 Teaching Data Structures Using Competitive Games IEEE Trans. Educ. 47, 4 p. 459–466.
[3] Milne I and Rowe G, 2002 Difficulties in Learning and Teaching Programming — Views of Students and Tutors Educ. Inf. Technol. 7 p. 55–66.
[4] Sharaf N Abdennadher S and Frühwirth T, 2016 A rule-based approach for animating Java algorithms Proc. Int. Conf. Inf. Vis. 2016–August p. 141–145.
[5] Dixit R K and Yalagi P S, 2017 Visualization Based Intelligent Tutor System to Improve Study of Computer Algorithms 30, 3.
[6] Junaidu S, 2008 Effectiveness of multimedia in learning & teaching data structures online Turkish Online J. Distance Educ. 9, 4 p. 97–108.
[7] Xiaoluo J and Han L, 2011 CDIO-based Embedded Systems Training Mode in Graduate Teaching in 2011 5th International Conference on Distance Learning and Education 12 p. 78–82.
[8] Lingling G Guowei T Yu F Jinhui L and Wanping Z, 2012 Research and Practice on CDIO-based Application-oriented Practical Teaching System of Computer Major Iieri Procedia 2 p. 24–29.
[9] Woollacott L C, 2009 Validating the CDIO syllabus for engineering education using the taxonomy of engineering competencies Eur. J. Eng. Educ. 34, 6 p. 545–559.
[10] Crawley E F Malmqvist J Östlund S and Brodeur D R, 2014 Rethinking Engineering Education .
[11] Mu Y You D and Dou Y, 2015 Cdio Training Mode of Programming Ability for Software Engineering Students Based on Acm / Ipc 1.
[12] Haller I Slowinska A and Bos H, 2013 MemPick: High-level data structure detection in C/C++ binaries in Proceedings - Working Conference on Reverse Engineering, Wcre p. 32–41.
[13] Zhulin L I, A Method for Data Structure Course Design Based on CDIO Teaching Idea 2 The Course Design Based on CDIO Model p. 418–421.
[14] Pham P A Nguyen M D Nguyen L Q Nguyen T M and Le B N, 2014 Learning Computer Programming in Cdio’s Team Settings Proc. 10th Annu. Int. CDIO Conf.
[15] Zamyatina O M Minin M G Denchuk D S and Sadchenko V O, 2015 Analysis of Engineering Invention Competencies in Standards and Programmes of Engineering Universities Procedia - Soc. Behav. Sci. 171 p. 1088–1096.
[16] Fadzilah N Rahman A Khalid N and Abdullah F, 2016 Web-Based Visualization Tools Of Data Structure & Algorithm – A Review Of Experience p. 27–33.
[17] Scott L and Iii C, Interactive System for Visualization of Linked List Operations in C++.  
[18] Elvina E and Karnalim O, 2017 Complexitor: An Educational Tool for Learning Algorithm  
Time Complexity in Practical Manner ComTech Comput. Math. Eng. Appl. 8, 1.