

# AN ACTIVE LEARNING ENVIRONMENT FOR TEACHING OBJECT-ORIENTED CONCEPTS, DESIGN AND IMPLEMENTATION

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Object-oriented concepts are able to reduce the semantic gap between the real world problems and the programming languages. Object-oriented methodology describes the software application in terms of objects. An object is a physical or conceptual entity that provides an understanding of real world problem and offers a solution. Although these features lead to massive productivity gains, they create complex relationship among objects that make it hard to study and comprehend.

In this work, we present an active learning environment tool to teach students the concepts, design and implementation of the Object-Oriented technique outside classroom. This learning tool is interactive as students play an essential role in the learning process. It is web-based that it can be accessed anywhere and it could be integrated to other learning management tools such as Blackboard or Vista.

Through this interactive learning tool, students will be able to study the object-oriented concepts, test their knowledge, and practice on designing the solution before they start the implementation phase. In the implementation phase, students will use the object-oriented language Java, which is the heart of this tool.

At any time, the tool will act as an available instructor to answer students' questions and reinforce the connections between the different topics. Students tend to have many errors when they start to learn programming and the "yellow shaded errors" make them embarrassed and create barrier between them and programming, which in turn can cause them to quit before they start. Using this interactive tool will break the barrier; make students more comfortable practicing programming during the learning phase; and hence improve the students' retention.

On the other hand, the tool provides the instructor with a way to communicate with students, monitor their progress and know about weaknesses and learning styles. Hence, the instructor can adjust his/her teaching method to match the students' needs.

## 1. Introduction

The object-oriented design methodology has become one of the leading techniques in problem solving. Compared to procedural programming, object-oriented programming is more natural and reliable [1, 2, 3]. It also has a high potential for reuse, and a relatively quick and easy way to implement and maintain. Recently, object-oriented programming has been widely accepted for designing and implementing software systems for various

application domains such as: air traffic control, high-energy physics, e-commerce, military systems, and others.

An object-oriented system as defined in [4], is made up of interacting objects; each maintains its own state. Object-oriented design processes involve designing objects classes and the relationships between these classes. A class is the blueprint for an object. It specifies the fields and methods a particular type of object has. From the class, one or more objects may be created.

Object-oriented systems are easier to change than systems developed using procedural approach. Object as an entity includes both data and methods to manipulate the data. Changing the implementation of an object or adding a service should not affect other system's objects. That is why there is a clear mapping between real-world entities and objects in object-oriented system, that improves the understandability and hence the maintainability of the design.

To develop an object-oriented system as a solution for a real-world problem, there are several phases students need to learn: analysis, design, implementation and testing. Like all creative activities, there is no clear-cut sequential process, but students should always start with analyzing the problem, then getting ideas for design and then implementing the solution. During the testing phase, they can always go back to the design phase in order to correct some errors or just refine their solutions.

In this paper, we introduce a web-based learning tool to teach students the concepts, design and implementation of object-oriented problem solving technique. The tool is very convenient for students as it will be available 24 hours/ day. It is designed to accommodate students with different background, various learning styles, and with special needs. The rest of the paper is organized as follows: the second section describes the different learning activities student will practice while using the learning tool. Section three illustrates the learning tool and the different modules it includes. Section four presents the expected results. Finally, the last section provides remarks and conclusion.

## **2. Learning Activities**

The Internet is a telecommunication medium providing open platform through a common browser user interface and a common network platform. This platform allows numerous information handling technologies to coexist. This technology is widely applied to education; providing sophisticated teaching and learning systems based on the common browser interface. Authoring and Web publishing are also developed as supporting tools and to provide better environment for education [5, 6, and 7].

A major challenge in engineering education today is making better use of currently available technology to dynamically adapt presentation of course material to students with different backgrounds and varying degrees of ability. To meet this goal, an instructional deliverable system must be employed to accommodate the following different learning styles:

- For active learners, allow self-motivated pursuit of information.
- For reflective learners, provide the opportunity to investigate and understand inter-relationship of material.

- For sequential learners, provide the opportunity to review the flow of lecture material.
- For global learners, allow navigation of computer course material under individual direction, but present a coherent association of previous, current, related, and future material.

From the above, it is clear that the Web-based learning has important educational implications. It presents exciting opportunities for distance learners and course providers. Therefore, our tool has many objectives including: providing high quality course notes; ability to access various information sources in different forms; offer an environment for students- instructor interaction; and ability to tailor individual learning paths.

Next, we introduce the different learning activities enforced by our web-learning tool. We recommend that students start with the concepts and background, and then start the analysis, design, implementation and testing sections. Some students go directly to the implementation, as they would like to expedite the learning process. In this case, we expect students to run into many errors and difficulties, which in turn refer them to previous learning activities to find out the source of errors and hence be forced to practice these learning activities. The details of each learning activity are described below.

### **2.1. Concepts and Background**

In this learning activity, students are introduced to the object-oriented concepts and they learn the differences between procedural and object-oriented programming. They will have their first look at classes and learn how to encapsulate both data and methods into a single object. This technique avoids many problems that appear when programs become larger and more complex. Students will also learn about information hiding and how objects typically hide their data but allows outside code to access their methods and hence protect the data from accidental corruption. Other object-oriented concepts are included such as reusability, maintainability, interaction and relationships between different objects in the system. We always recommend that students start with this learning activity to prepare themselves for the other learning activities to follow.

### **2.2. Analysis**

In this learning activity, students should learn important analytical skills. They start with real-world problem; they learn how to break it down into smaller sub-problems. For each sub-problem, students should develop an understanding of its context, how to provide a software solution as a sub-system, what is the required functionality of the software and how to structure the software solution to communicate with its environment. For each sub-problem, students should determine a task, all input and output variables calculated by this software solution, and other related subjects. In addition, students should learn how to integrate the sub-systems together into one system that would represent a complete software solution to the real-world problem.

### **2.3. Design**

In this activity, students learn how to describe the major components that make up the system and their interactions. They make use of the information from the analysis phase and map all real-world entities in the problem into software objects, determine their

data and operations. Students also learn to specify the relationships between different objects in the system such as association and inheritance [8]. Association relationship appears when one object is part of another object, while the inheritance appears when a class extends an existing one. Our tool provides all the information and the enforcement that support the above tool activities.

#### **2.4. Implementation**

In this learning activity, students learn to realize the software design resultant from previous learning activity as a set of programs or program units. Java programming language is used in this learning activity. All Java syntax and rules would be enforced. After the analysis and the design phases, it will be easy for students to transform the software solution into Java code. This learning activity also includes programming tips and common errors to be avoided. Our tool interacts with the students to help them in developing and testing different Java constructs. That is achieved by presenting the structure of the Java segment of the code and interactively help the students to type the different parts of the code and correct its syntax. This allows the students to learn the correct way to code different Java constructs in an easy and more convenient way.

#### **2.5. Testing**

Testing is the last learning activity as students learn how to test their Java code, detect and correct the different errors that could be categorized into three groups: syntax errors, run-time errors and logical errors. Syntax errors can be detected by the Java compiler, it generates a list with all syntax errors when the code does not match the rules of the Java language and all “yellow shaded statements” are highlighted for students with hints to help correcting these errors.

The second type of errors is the run-time error, which can't be picked up while compilation but it is detected when the program runs. There are many reasons to trigger a run-time error the most common is when the program tries to access a non-accessible memory piece or server.

After correcting all syntax and run-time errors and the compilation and run of the program are completed successfully, students can run into logical errors. When the results the program produces, are not matching the expected ones that is know as logical error. In this case, students learn how to debug the program and trace the code to find the source of error. To correct such an error, student may discover a problem in the design phase hence they need to go back to the design phase to re-design and then re-implement and re-test the program. Our tool includes more than one phase that supports such activity and all others (to be discussed next).

### **3. Web-based Learning Tool**

In this section, we introduce our web-based learning tool to teach students various object-oriented concepts, help them analyze, design and implement a software solution for real-life problems. This learning environment also allows the students to test their knowledge and practice exam questions. The tool is interactive where the student plays a crucial role in the learning process. The student would be able to decide about the level of

difficulty, repeat some modules with different difficulty levels, check Need-Help icon for difficult modules when s/he needs extra help. Moreover, the student would be able to submit questions or comments to his/her instructor and receive the instructor's response back. The different modules in the learning tool, as shown in Figure 1, are described in the following sub-sections.

### **3.1. Information Module**

It provides the fundamentals of object-oriented properties, analysis, design and implementation. It demonstrates the basic knowledge of classes, objects, methods, and the relations among them. It also presents students with the main programming constructs used in Java (including purpose, syntax, use, examples, programming tips, common errors, self-tests, etc.) as shown in figure 2. This facility will be different from the lecture and the class notes in giving wider selection of examples and reinforcing the connections between topics. In addition, material can be recalled and projected. Also, students would have the opportunity to go over the material any time and more than once.

### **3.2. Problem-Solving Module**

The students will access this module to apply the knowledge gained through the information module. This module includes all the learning activities illustrated in section two. It has a wide selection of examples of real-life problem and the accompanied results of using each learning activity. This module reinforces the connections between the different learning activities and shows how the output of a learning activity would be used as the input of another one. Each problem in this module is intended to illustrate some programming language concept and/or object-oriented problem solving technique. This module will also help the student in an interactive mode to implement and test his/her problem solution. Then the system will report, to the student and the instructor, the concepts and the techniques that need more study.

### **3.3. Exam Module**

This module provides students with exams to reinforce material presented in the problem-solving module and to facilitate retention of the material. Short and fast quizzes will be built into this module to recall the important points of each subject, or to review prerequisite material. When students review these quizzes, incorrect answers bring up text fields on the screen, which explain why the answer is incorrect. The exams in this module are organized as multi-level structure where the first level is the easiest. After taking the exam, the tool displays the student's grade together with some recommendation to review specific learning activity or problem-solving concept(s). All exams are saved in the exam bank as shown in Figure 1, so the instructor may change exams and quizzes every term. Each student should sign up for an account in order to be able to access this phase or just use the student account in case this tool is integrated with Vista or Blackboard learning management tool. The student account saves the topics studied, tests taken and the grades earned in each test.

### **3.4. Instructor Module**

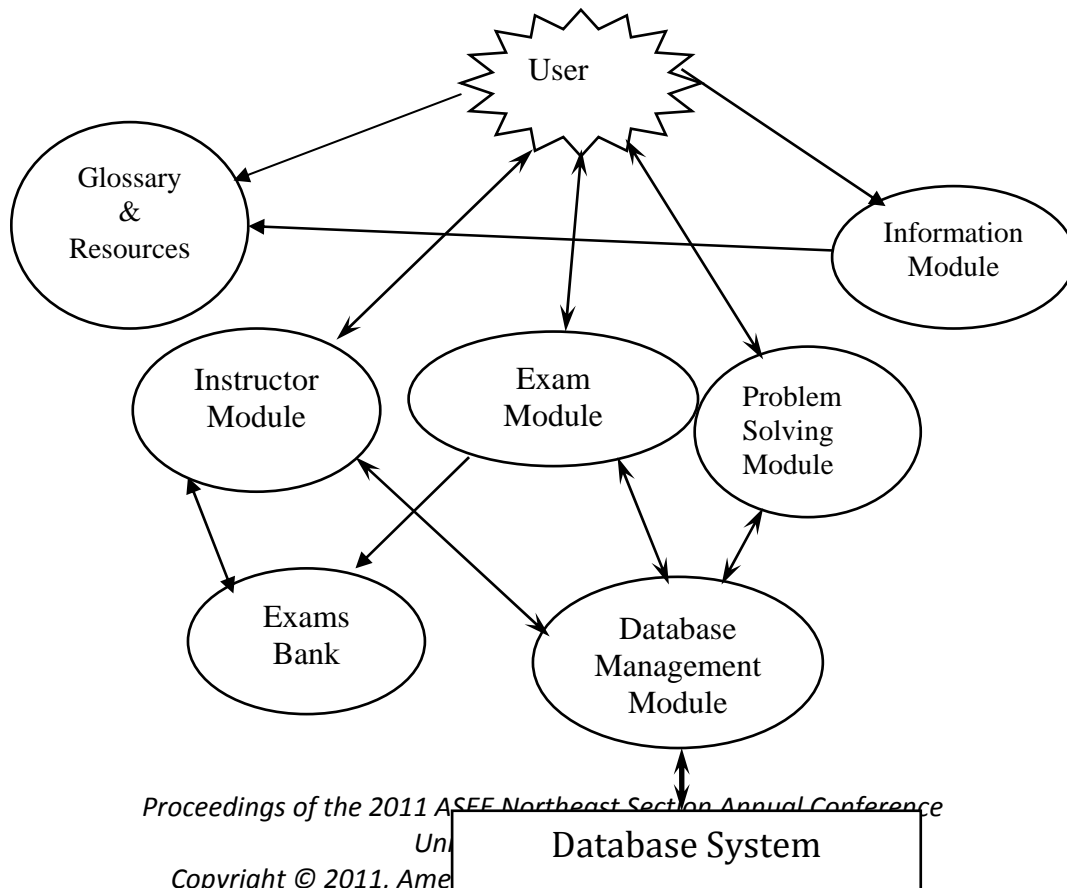
Through this module, the instructor will be able to edit student's records, monitor his/her performance, and diagnose his/her problems. It allows the instructor to broadcast different course materials, modify and enhance the learning environment capabilities, add, change or delete modules according to students needs. It also allows the instructor to evaluate all the submitted work and respond back by recommendations and comments. Through the different activities of this module, the instructor can investigate and examine ways to help students of special needs.

### 3.5. Glossary and Reference Module

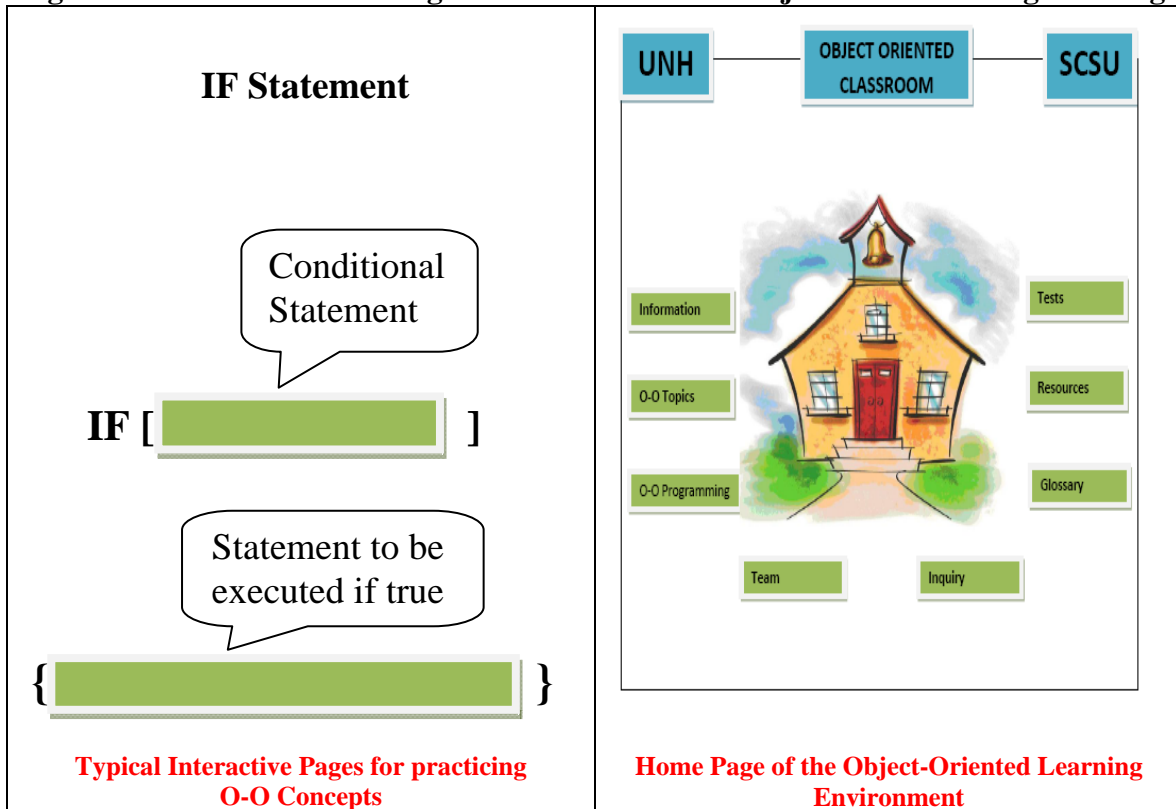
This module includes two different glossaries. The first glossary includes the key terms and definitions of the object-oriented concepts while the second glossary includes the Java programming language terms, Java operators, API's and standard libraries. Moreover, the second glossary includes a list of the Java language reserved words, primitive types, their sizes, etc.


### 3.6. Database Management Module

This module controls all the learning tool activities and holds all related information. The database system will be also used to hold a progress report for each student enrolled in object-oriented programming course in specific term. The database will be also used to store all sets of exams, quizzes, course notes, and any other information needed by the students. The Database Management and Network module works as an interface with the database system. The database size is determined according to the number of students taking the course. In case of increasing the number of classes offered, the database size should be increased.



**Figure 1: Web-Based Learning Environment for the Object-Oriented Programming**



<h3>Exercise</h3> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: fit-content; margin: 10px auto;">       Enter a condition that matches the print statement     </div> <pre> <b>IF</b> <span style="background-color: #90EE90; border: 1px solid black; display: inline-block; width: 100px; height: 15px;"></span> <b>]</b>        <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: fit-content; margin: 10px auto;">         Statement to be executed if true       </div> <div style="border: 1px solid black; border-radius: 15px; padding: 5px; width: fit-content; margin: 10px auto;"> <pre> { System.out.print ("You have more apples than bananas") } </pre> </div> </pre> <p style="color: red; text-align: center;"><b>Sample of Web Page for Question and Answer Related to O-O Concepts</b></p>	<ul style="list-style-type: none"> <li> Introduction to Programming</li> <li> Variables and Types</li> <li> Conditional Structure</li> <li> Loops</li> <li> Methods</li> <li> Classes</li> <li> Arrays</li> </ul> <div style="text-align: right; margin-top: 20px;">  </div> <p style="color: red; text-align: center;"><b>Object Oriented Topics of the Main Page</b></p>
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**Figure 2: Samples of the Web pages of the Object-Oriented Learning Tool**

#### 4. Expected Results

As mentioned before, the Web-based interactive learning tools have important educational implications especially in schools, which offer programming classes in lecture format only (i.e. no lab session). They present opportunities for distance learning and course development. They especially provide great deal of support to students who require special needs and more attention. They also help the instructors to server their students better and update their teaching styles.

We are in the process of developing this Web learning environment tool for the object-oriented programming, Figure 2 represents samples of the web pages of the learning tool. It is expected that such a tool will help our students dealing with the object-oriented classes we offer at UNH and SCSU since they are offered in lecture format only. It will also improve the students' retention. We have different parts of the tool developed and used to support the current offers of these classes (see figure 2). The project work is going on to develop the other parts of the tool and integrate the overall system.

We had previous experiment in developing and using such Web-based learning environment presented in [9]. This work was well received by all the engineering students, instructors, and web-site visitors. The tool had a great impact on the students' success and improved their retention. It is expected that the object-oriented tool will be powerful educational tool and more successful one.



## 5. Conclusion

In this paper, we introduced a web-based learning tool to teach students object-oriented concepts and walk them through the different development phases: analysis, design, implementation and testing. The tool is a convenient learning environment for students as it will be available all the time; it gives them a chance to test their knowledge and learn more about the topics outside the classroom. This will increase the students' retention and improve the faculty effectiveness and efficiency.

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