

# An Active Learning Approach for Teaching Web Development- Action Research Study

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**Abstract**— This paper presents an Action Research study for incorporating new learning and teaching methods into a Web Development module at a U.K. University, addressing the problems of varied experiences amongst the students with programming languages and computational thinking. Active learning concepts were introduced using three experiments involving Learning by Teaching, Jigsaw Puzzle, and Observations from Videos. These experiments were aimed at enhancing the students learning capabilities and computational thinking. All three experiments have achieved positive results among the students who were evaluated using formative assessments during their practical sessions. The study has found that Active Learning concepts can enhance student learning capabilities and give them more control over their own learning.

**Keywords**- Action Research; Active Learning; Teaching; Web development

## I. INTRODUCTION

Action Research in education, unlike other approaches focuses on ways of identifying strategies to improve skills and techniques of the researcher/teacher so that effective delivery methods can be incorporated into the teaching according to the various issues identified with the students. For example, qualitative and quantitative approaches or a mixed approach including both qualitative and quantitative may be effective in analyzing a particular issue or context, but they lack a collaborative and a democratic approach, which can be identified in Action Research [1] [2] [3]. In addition, Action Research offers a continued reflection on a problem or issue, where the goal is continuous improvement of the processes to address the problems [3]. Further, Action Research focuses on doing things better rather than investigating why we do those said things, and on identifying and adopting a change in teaching methods to achieve a positive impact for students [8]. A more detailed explanation of Action Research was identified in the works of Watts [23], which states that Action Research is a disciplined inquiry done by a teacher within the context of a teaching environment that would identify and inform the changes to be adopted in the teaching practice/methods. It is a continuous practice that has to be adopted by teachers to identify the solutions to changing

problems and to deliver the best and most effective educational outcome.

According to Watts [23], the objectives/practices of Action Research in teaching and learning processes include the following:

- Educators should work best themselves on identifying problems in the teaching environment.
- Educators should be more effective in identifying problems and considering ways of working differently, which could be more effective compared to more traditional methods.
- These processes should also aim for professional development.
- A collaborative approach has to be practiced involving students and other teachers in identifying best practices.

It is also essential to understand the characteristics of Action Research that makes it unique and different from other research practices. Various characteristics of Action Research were identified in [22], highlighting it as an innovative and continuous approach, which is strategically driven, participatory in nature, adopting an intervention approach by implementing a solution to the problem identified, and the whole process is documented, understood and disseminated. Therefore, Action Research is different from scientific research in many aspects including the objective, methodology and the motivation and purpose. Action researchers typically do not use complex statistical procedures involved in quantitative research to evaluate results; however, they do offer other evidence (such as comparison with similar data) in order to prove that their measures are reliable and valid [3]. Action Research is focused on continuous reflection and improvement rather than focusing on the final outcome or conclusion, as observed in many scientific research studies. Various studies [29]-[32] have implemented the action research methods, and found it very useful in the long-term process. In the study performed in [29], inquiry-based classroom discussions were used as a method for developing the higher order cognitive skills among the chemistry students. Similarly, action research methodology can also be used for analyzing and promoting the learning process of students in computing programming module in a blended

learning environment [30]. Similarly, online journals learning was used as an approach in the study performed in [31] through action research for promoting the learning computer applications and network programming. Other approaches such as Boolean Ninja, Minimum Spanning tree were used as the part of study in [32] for developing the critical thinking and computational abilities among the computing students. The approaches adopted in these studies were depending on their objective and the areas of problems identified. However, the aspects of collaborative approaches and active involvement in action research were not focused to a great extent in the research studies relating to the computing programming modules.

The Action Research process involves various stages. Different authors have described different stages, which can be summarized into the five main stages [8] as shown in the

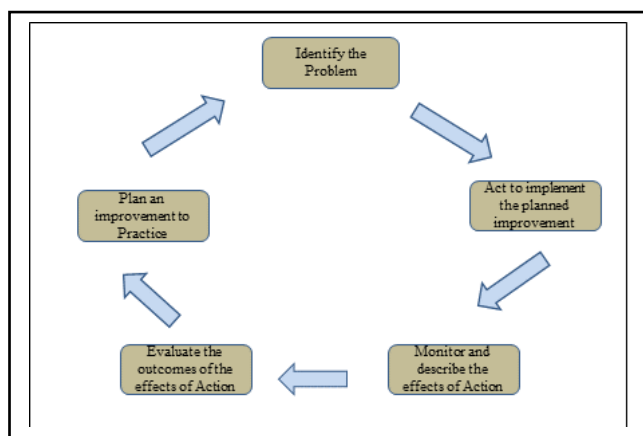


Figure 1. Stages of Action Research

The five stages explained are used for identifying the problems and conducting the Action Research using various techniques. The impact of these techniques including ‘learning by teaching’, ‘jigsaw technique’, and ‘video observations and reactions’ on the learning and development process of the web development students is investigated in this study.

The rest of the paper is structured as follows. In Section 2, we present the design and the process of action research with web development students, which included the problem identification, improvement planning process, implementing and monitoring the actions, evaluating the effects of the planned actions, and planning the improvement. In Section 3, we present the limitations and challenges observed in this study; and Section 4, concludes the study.

## II. ACTION RESEARCH WITH WEB DEVELOPMENT STUDENTS

The web development module is a comprehensive course which is designed to educate the students with the various technologies used in the web design and development. The course syllabus can be summarized under the following points.

- Responsive web design using HTML5 and CSS3

- Web Information Architecture and Content Management Systems
- Web development using Java along with underlying technologies including C#, C++, ASP, LINQ
- Client-side and Server-side Programming
- Patterns and methods to enhance maintainability and testability
- Applying business logic
- Testing, deployment and configuration
- Performance modelling and management

The aim of this course is to educate the students in all the major spheres of web development and management. Accordingly, the teaching process focuses on programming and coding to the large extent with the regular lectures explaining the major concepts.

In order to incorporate Action Research techniques into the teaching process and improving the skills and educational outcomes of Web Development students, a strategic approach was formulated which is explained in the following sections.

### A. Problem Identification

One of the important stages of Action Research is the identification of the problem. There are various approaches such as questionnaire surveys, interviews, observations, checklists etc. that are available for identifying the problem by involving the population in reflecting their opinions [27]. However, surveys and interviews are the most commonly used approaches in this process; surveys can be used to assess and identify the issues, while interviews can be used for in-depth analysis of the issues or problems [28]. It is necessary to identify students learning issues related to the module, and also the topics which cannot be understood by the students, so that the effective learning strategies can be planned and implemented.

In order to assess and understand the problems faced by students in understanding the concepts of a Web Development module, a questionnaire-based survey was carried out. The questionnaire was designed with ten questions in two sections. The first section had six questions focusing on the student abilities, where they are required to answer the topics which their awareness, expertise and experience related to various topics in the web development module. The second section had four questions related to the learning abilities and their feedback of using different approaches in teaching, such as collaborative approach. All the students attending the module (30: 19 males; 11 females) participated in the survey. Among the 30 students, 22 students belonged to the age group 20-25 years; and eight students in 25-30 years age group. After analysing the survey responses, it was identified that the lack of experience in programming languages and computational thinking skills among students were the main problems affecting their understanding of the concepts in Web Development. These problems are mostly focused on the students past learning and abilities. Such problems require active involvement of students in learning on their own and making them

responsible, confident and able to take charge of their own learning. Considering the case, Active Learning methods and techniques were identified as the best strategy for achieving the effective educational outcomes.

Active learning is a process of engaging students in the learning process using different techniques. Unlike a more traditional approach where students might listen while lecturers explain, Active Learning requires the engagement of students in various learning activities through collaboration. In [6], it was stated that students must do more than just listen, which includes reading, writing, discussing and engaging in solving problems, and adopt higher order thinking in tasks, such as analysis, synthesis and evaluation. In short, students are involved in doing learning activities, thinking about the concepts and also what they are doing. Several studies have shown greater improvement among the students by adopting Active Learning techniques [17]-[19].

In Active Learning, students are constantly processing what they are learning through discussions, debating, writing short notes etc. Various benefits have been identified by the authors in different settings. Interactive courses were found to be more effective in promoting conceptual understanding as compared to traditional courses [11]. In addition, the meta-analysis of 225 studies across STEM (Science, Technology, Engineering & Mathematics) conducted in [10] has found that average exam scores of the students were improved by 6% by adopting Active Learning classes; and also, students following traditional lectures were 1.5 times more likely to fail compared to the students following Active Learning classes.

Computational Thinking is one of the effective techniques used in problem solving, application development, system designing etc. It can be effectively applied in both computer programming courses and also in other courses [20]. It includes the use of various techniques such as decomposition (breaking down data into smaller parts), pattern recognition (observing patterns/regularities), abstraction, designing etc. [24]. Realizing its importance, The International Society for Technology in Education (ISTE), Computer Science Teachers Association (CSTA) and the UK Computing at School working group (CAS) have collaborated with representatives from education and industry to develop computational thinking resources for educators [21].

Considering these factors, using Active Learning methods in teaching practices for a Web Development module could help to solve the problem and increase students' achievements. Thus, the following research question was formulated.

*How can we use Active Learning methods and techniques to mitigate the problem of different skill sets and capabilities by helping the student to be in charge of their own learning?*

#### *B. Planning an implementation of Improvement*

An action plan usually involves the process of deciding a new strategy or approach for addressing research questions;

identifying the data needed to learn about the research questions; framing an approach or timeline for implementing the new strategy; and a plan for evaluating the findings from deploying the new strategy [5] [16].

Accordingly, the problems and the interests of the students from the Web Development module were identified using a questionnaire-based survey as explained in the previous section. The subsequent data analysis has shown that the students were interested in adopting Active Learning techniques for addressing their concerns and enhancing their skills and learning capabilities. Considering these outcomes, the approaches in teaching should be focused on actively involving the students in the learning process. Learning by teaching is one such approach, which directly involves the students in learning the concepts by teaching. In addition, as the students attending the module are from different regions with varying learning abilities, collaborative approaches can be very effective in the process of learning [2]. However, there is a need for approach that requires collective efforts of all the students in the learning process, so that all the students can be benefitted from these approaches. In addition, as discussed in the introduction, the use of collaborative approaches was not explored to a great extent in the computing learning environments. Therefore, approaches such as, learning by teaching, Jigsaw Puzzle, and Video observations were selected as a part of this study. Accordingly, three rounds of experiments were planned over a period of three weeks with each session of 3 hours duration. Each experiment used Active Learning techniques to deliver the concepts relating to each chapter of the Web Development module. A formative assessment was used for evaluating the experiment which focused on using the programming exercises during practical sessions.

#### **a. Experiment 1: Learning by Teaching**

Learning by teaching is an effective Active Learning technique that has been widely recognized and tested [9]. It is a process where students are asked to teach the concepts of a particular subject or chapter in a class which would be monitored by a teacher and corrected if necessary. This process actively involves the students in the learning process as they feel more responsible in explaining the concepts and more attentive due to the social presence in the class room. This approach was found to be more effective compared to other techniques like re-study or writing [12]. Therefore, using this technique, the students from the Web Development module were asked to teach the concepts of HTTP Methods in the class room. The effectiveness of the experiment was evaluated during the practical sessions.

#### **b. Experiment 2: The Jigsaw Technique**

The Jigsaw Technique is a form of teaching strategy adopting principles of cooperative learning that helps students to develop skills for effectively working in teams or in collaboration with one

another. It focuses on cooperation rather than competition among students and is one of the most supported techniques within the education field as evidenced by more than 1200 research studies [15]. It helps students to understand a concept, apply the language of the discipline and practice self and peer teaching [7]. The technique usually gives a common task to all the students/teams. These students/ teams initially have to solve a problem and identify the relevant issues, which they later discuss with other students/teams. After collaborating with other students and identifying different issues, the best possible solution is formulated by those students for addressing the common task.

Using this technique, the students from a Web Development module were given a task (piece of puzzle), which initially they need to solve on their own. Later they need to collaborate with other students to find the most effective solution to the puzzle. The puzzle is about building the most effective algorithm to travel from the University main compass to a local international airport. This task gave students the idea of designing an algorithmic solution to a given real life problem through individual thinking and team work. This approach would also enhance the students computational thinking capabilities, as well as training them in the process of simplifying complex problems into simpler issues by breaking the problem down into smaller parts. This approach was then evaluated during practical sessions.

### c. Experiment 3: Videos Observation and Reaction

Using multimedia content in teaching has been widely practiced across various institutions [13]. It has many benefits compared to traditional modes of teaching [25]. Using videos for teaching and enabling students to observe the important aspects from those videos is one of the techniques used to increase student observation skills and understanding various issues [4]. Studies have proved that videos can be used effectively in teaching and can attract students' attention and improve their skills [26].

Using video as a tool for observational learning, students from a Web Development module were given carefully chosen short videos from the Big Bang Theory comedy series to watch. These videos were related to team work, collaborative working, and project management. The students were distributed into two groups. The first group was assigned with the task of identifying the positive things from the videos; and the second group for identifying the negative things, which they would link to their group projects and assignments. This

experiment was then evaluated during practical sessions.

### C. Monitoring and describing the effects of the actions

All of the three experiments were carefully monitored and the observations were recorded. In the first experiment (Learning by Teaching), the students were asked to teach HTTP Methods, both GET and POST functions to be used in the Web development and also how the HTTP request cycle operates (the module concepts which the students found difficult in programming: observed from survey results). Though the students were initially nervous, they were able to quickly adapt to the teaching technique and reflected their understanding of these concepts in an effective way. Some corrections and suggestions were made to the students while they were teaching to boost their confidence and correct their mistakes.

The second experiment (Jigsaw Technique) was used for enhancing the computational thinking of students. Majority of the students (76%) stated that they face problems in designing the sorting algorithms. To address this issue, the students were asked to build the most effective algorithm to travel from the University main campus to a local international airport; first by working individually, and then in collaboration. The experiment was monitored and tips were given to students while working in groups on identifying the main points and issues in formulating the best possible route.

Another important issue identified from the survey results was that, 86% of the students had problems in identifying the right requirements and reflecting them in the coding. As this process requires the identification of right set of tools and commands in coding, the students are required to develop critical thinking capabilities and clear observation and analysis skills for selecting the right set of tools and commands in coding. Focusing on this aspect, the third experiment (Videos) was given to students from two groups and tips and examples were given on how to identify the positive and negative aspects of the videos.

### D. Evaluating the outcomes from the experiments

Evaluating actions is one of the most important tasks that can be used to identify if the planned improvement has a positive impact in addressing the problems identified. The first experiment was evaluated during the practical sessions of a class using formative assessment by asking the students there to build a simple HTML form and send messages using GET and POST functions. Interestingly, most of the students were active, engaged and completed the task within the given time and this was compared to students from a previous semester who were not exposed to these Active Learning techniques. 28 students out of 30, completed the task successfully compared to the 19 students who successfully completed the same task in previous year, reflecting a significant improvement in the learning process.

The second experiment (the Jigsaw Technique for algorithmic routing) was evaluated by asking the students to design UML activity diagrams and a flowchart to solve the given real-life problem. The students were found to be effective in adopting the concepts of simplifying complex problems into simpler issues by breaking them down. This was then reflected in their design diagrams and an improvement in their computational skills was observed in designing a flowchart for a real-life problem. Interestingly, all 30 students were able to effectively design the UML diagrams and flowcharts. Only 16 students in the previous year were able to complete this task successfully. The results indicated that collective efforts of the students through discussions, knowledge sharing, team management etc. were found to be significant in solving the problems, leading to the overall development of students.

The third experiment (Videos) was evaluated by asking students to create a group work plan and a Gantt chart for their group assignment. Almost all of the students effectively categorized and identified the tasks for the group work and systematically created a work plan, which was effective and easy to implement. Almost 26 students clearly identified the activities/steps involved with appropriate time schedule for each activity. The results indicate the improvement in the planning, assessment and project management skills of the students, where they need to identify all the relevant tasks, activities, risks, and plan the project/assignment.

#### E. Planning an Improvement

Overall, the three experiments based on the Active Learning concepts were found to have a positive impact on enhancing the student experiences in using programming languages and their computational thinking. Considering the outcomes of the experiments, these Active Learning techniques are now planned to be used in future teaching of Web Development concepts classes.

### III. RESEARCH CHALLENGES AND LIMITATIONS

One of the major challenges identified was about identifying issues or problems associated with the students. The students in the Web Development module were diverse coming from different nations, cultures, and with different experiences and skillsets. While some students had job experience, others did not. So, identifying the differences and getting all of them on a single platform was a big challenge, which was addressed by using a questionnaire-based survey. Other challenges included identifying a suitable pedagogical approach, common interests of students with the type of new learning methods, and their expectations associated with the individual style of teaching being delivered. These issues were addressed by collecting the responses through surveys and discussions, and deciding mutually for using Active Learning techniques as the solution for addressing the identified problem.

### IV. CONCLUSION AND FUTURE WORK

Action Research was used for addressing the problem of students with varying skillsets and experiences in understanding the concepts of a Web Development module using Active Learning techniques was the main idea behind this work. Using Active Learning techniques especially the Jigsaw Puzzle have given positive results, and this experiment has led the way forward for introducing new pedagogical approaches in teaching. Finally, this approach could be used continuously to identify changing issues and problems and addressing them using this most effective method of learning and teaching.

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