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Experiences gained from the deployment of an E-Learning "Java Arrays" Prototype for novice Java programmers in the Institute of Technology Tallaght, 2002/2003

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Abstract

This paper describes recent experiences gained from the deployment of an E-learning "Java Arrays" prototype for novice first year students within the Computing department at the Institute of Technology, Tallaght. It attempts to determine what contributions, if any, the E-Learning prototype made to novice students learning to declare, create, initialise and manipulate one-dimensional and two-dimensional arrays within the Java Programming language. Tentative conclusions from this process are presented and a charter for progressing this research further is outlined.

1. Introduction

This research paper is the second paper in a broader "Java and E-Learning" based research study that is being conducted in IT Tallaght since the academic year 2000/2001. The first paper ("Initial experiences gained and initiatives employed in the teaching of Java programming in the Institute of Technology Tallaght", Eamonn Hyland, Gary Clynch, PPPJ Conference 2002, TCD) sought to evaluate, among other items, the student's perceptions of our Java Syllabi and they were asked to rate topics they had covered in terms of levels of learning difficulty. The primary result of that study was that "Arrays" emerged as the most difficult concept that our novice student's had covered in terms of learning difficulties and levels of understanding. This outcome formed the basis and rationale for the development and deployment of an E-Learning "Java Arrays" prototype in the department to be utilised by the next group of novice students in the coming academic year. The E-learning prototype was developed and was made available to students in a strictly controlled fashion during November 2002. Data was gathered using a series of detailed and phased knowledge based questionnaires, which were presented to the students at regular intervals while they were studying the Arrays section of the Java software development stream. The overall aim of this research was to measure the effectiveness of the prototype in terms of its contribution, positive or negative, to the students learning experience.

The structure of this paper is as follows. Section 2 gives a brief description of the environment in which the study was undertaken. Section 3 describes in more detail the rational and design of the study. Section 4 describes the E-learning prototype as developed and deployed throughout the study. Section 5 provides the results of the study and presents an analysis of these results. Section 6 provides the conclusions reached as a result of this study.

2. Introduction to the study environment

The study was performed within the Department of Computing at I.T Tallaght. The student groups surveyed were completing the first year of a 2-4 year programme, which can lead after year 4 to a B.Sc. in Computing (Information Technology). There were approximately 180 students in first year when the study took place, divided into 10 classes for software development. The class sizes are deliberately kept under 20 students to facilitate timetabling of these classes into our 20 seater special purpose teaching laboratories (interactive whiteboards, teacher's console with synchronisation and presentation software to control the student's machines similar to an advanced training environment), outlined in detail in the initial paper. The software development courses are delivered using a combination of interactive lectures, tutorials, and laboratory sessions and are assessed with practical in lab assessments where students design and code their programs. The assessment phase tests the student's ability to apply the new skills they have learned solving IS programming problems.

3. Study rationale and Design

As stated in the introduction, this research was a natural follow on study based on the outcomes of the first paper (PPPJ 02, TCD). That paper had presented the results of an investigation into the success of various pedagogical initiatives employed teaching programming, and also questioned the student's perceptions of the Java syllabi, within the Computing Department at I.T Tallaght. To determine the student's perceptions of the syllabi topics, the researchers had conducted a qualitative based research survey. The study identified and weighted concepts in Java which students had difficulty understanding. Of the students surveyed, over a quarter (28%) identified Arrays as the most difficult topic. This main finding was considered significant in the context that these students were now in second year and had covered advanced topics such as classes, inheritance, encapsulation, but they still had difficulties with "Arrays", one year after covering it on the first year syllabus. This provided a basis and a rationale for designing and implementing an E-learning prototype exclusively

designed to help students learn and understand and apply arrays. The prototype would then be assessed to determine any identified contribution to addressing this identified learning difficulty with Arrays in Java. If the outcome of this study is encouraging or at least not in any way detrimental to learning, the prototype can then be further integrated into the Computing Department's software development teaching model.

Two student groups were chosen to partake in the study, one would use the prototype and one would not. The same lecturer was chosen to teach both of these groups separately to eliminate any bias with different lecturing styles. The prototype was installed in a Computing Department teaching lab on all students PC's in a controlled fashion. The prototype was made available to one set of students as a supplementary learning tool to the traditional methods while the other group was taught "arrays" using only the traditional methods already in place in the college, course notes, laboratory sessions and tutorials. The topic of arrays in Java, as taught within I.T Tallaght, covers 3 main sections 1) array initialisation and declaration, 2) array manipulation and 3) two-dimensional arrays. For the group using the prototype, they were required to write Java code statements or programs within the simulated environment to create and manipulate arrays. The group not using the prototype could use the Sun Forte IDE environment to do this as normal. Questionnaires were deemed the most suitable means of capturing data to meet the objectives of the study. Detailed questionnaires were designed based on a clear set of objectives to accurately capture how well students in both test groups understood the concepts in the 3 main sections. The questionnaires consisted of multiple-choice questions, true or false questions, as well as open ended questions such as "Write code to…", "Describe what is …", and "Explain this concept". An extra questionnaire was also designed which was distributed at the end of the study. This questionnaire was only given to students who had access to the E-Learning prototype. It was more qualitative in nature and it focused specifically on the prototype itself and how effective the students *felt* that the prototype was. The questionnaires were handed out at the end of classes in which a particular section had been completed. Students were allocated as much time as they needed to complete the questionnaires.

4. E-Learning prototype design and implementation

Various development environments were considered including implementing the prototype as a Java applet, using PERL, C++ based CGI scripts, HTML, Macromedia Flash, Java, TopClass and Blackboard. Flash was deemed to be a viable development environment due to its visual

strengths and its ability to deliver a fast web based application. In terms of distribution, it would require merely a plug in the target PC's, and in the Computing Department at I.T Tallaght it is already installed as part of our generic download. Flash uses a scripting language, ActionScript, which facilitates ease of implementation and debugging facilities. It provides powerful control of a rich Multimedia interface, which can incorporate and control graphics, text and sound. Using this development environment meant that the prototype could be converted into an executable form for use on a student's PC at home. Also as long as a host machine had the Flash plug-in installed the E-Learning prototype could be used remotely or streamed over the Internet from a remote server.

The prototype was designed with a strong visual GUI interface, to be simple and intuitive to use. In development terms, most of the effort was spent developing a Java Parser Engine. This Engine works behind the GUI to interpret Java individual code statements or indeed Java programs entered by the student. It can then represent arrays visually "on the fly" that were declared by the student's Java code. The Parser Engine consists of a basic lexical analyser/syntax checker that recognises a pre-determined set of Java statements and operators. It is fully extensible and will no doubt incorporate further learning concepts as the E-Learning experiment continues. It works in the following way: as students assign values to array elements the array can be seen visually on the screen. Only an array up to 8 wide and 8 high can be displayed onscreen although larger arrays can be declared and populated. The prototype is standalone, and does not record or monitor a student's performance. Instead it focuses on the repetition of entering code, correction of errors and visualization of results of the program entered. The prototype GUI consists of a single screen that does not change and is sub-divided into 3 areas:
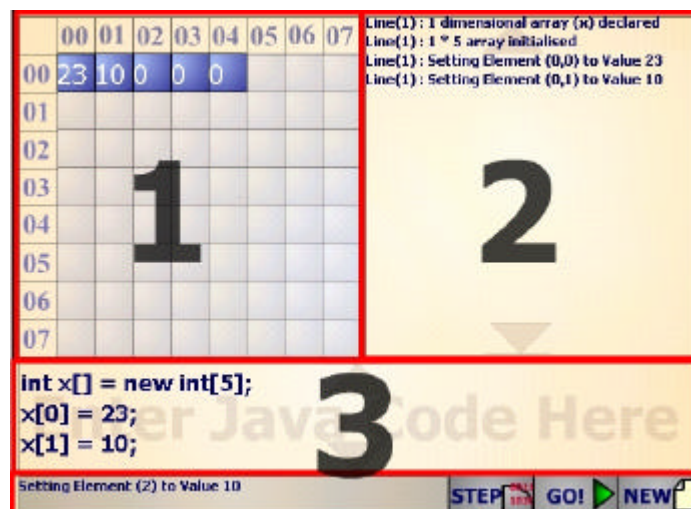
Area 1. Displays an 8 * 8 grid of the created array with the values stored in each element.

Area 2. As each line of code is executed a "feedback" message is displayed indicating what action is being performed.

Area 3. Area where user enters their Java code to create and populate the array. Basic controls to Step through a users code, execute a users code or create a new program are also provided.

5. Survey results and Analysis

This section provides an analysis of the survey results to attempt to draw conclusions as to the effectiveness of the E-Learning prototype and any contributions it may have made to enrich the learning experience of the students. The questionnaires were designed to ascertain the general group level of knowledge and understanding within each distinct Array concept. The results of these groups can then be compared against each other to determine what effect if any the E-learning tool had on the student group who used the prototype. The tool may have had a positive, negative or null effect on the students learning experience.

Before the study began, the previous performance of the two classes was noted by analysing the results of the practical in lab Continuous Assessments that they had recently completed and being graded on. The calculations used the average results that were gained and average performance of each group is summarised below.

	Group1 (No Prototype)	**Group2 (With prototype)**
Assessment # 1	74.47%	61.85%
Assessment # 2	62.78%	58.38%
Overall Average %	68.63%	60.12%

This average percentage was used to determine a relative performance difference between the two groups initially, so that this difference could be taken into account after the study had been completed.

The first questionnaire was given to the students after the concept of array declaration and initialisation had been covered. The questionnaire contained a set of multiple choice (closed questions) and open-ended questions such as

> *"Write code to declare and initialise a 5 element integer array called myArray"*
>
> *"Describe what an 'Array' is in your own words?"*

The second and third questionnaires were distributed during and after the concept of array manipulation. These questionnaires also contained sets of multiple choice and open-ended questions such as

"What is the output to the screen if the following code is executed"

int [] MyArray = {1,2,3,4,5};

```
for (int i=0;i<MyArray.length;i++)
{
        System.out.print(MyArray[i] + " ");
}
```

The fourth questionnaire also followed the same style design as the first, second and third questionnaires, but focused on Multi-Dimensional Arrays.

Each set of questionnaires was assessed and graded for both groups and an average percentage based on knowledge and performance was calculated for each group. The average percentage based on each questionnaire for each group is summarised below.

	Group 1 (No Prototype)	Group 2 (With Prototype)
Array Initialisation	96.87%	85.73%
Array Manipulation #1	75.45%	80.68%
Array Manipulation #2	60.76%	43.85%
Multi-Dimensional Arrays	73.33%	65.71%
Average Group performance	76.61%	69.01%

The fifth and final questionnaire focused entirely on the E-Learning prototype itself and was only distributed to the group that had been using the prototype during this time. This questionnaire consisted primarily of closed questions, which attempted to ascertain any positive or negative qualities the students liked or disliked about using the prototype. These questions asked the students for their own opinions as to how the prototype affected their learning experience.

"Did the tool help you 'create' your own arrays?"
"Did you 'like' using the E-learning tool"?

A substantial amount of student feedback was gathered, based on this final questionnaire. All students who returned a completed questionnaire felt that the prototype had helped them to

increase their basic knowledge of arrays. When asked to explain how the prototype had increased their knowledge and understanding, students replied with comments such as

> *"It makes it easy to see where things are coming from"*

> *"It actually shows you what happens and where it happens. It makes it easier when you physically see what happens"*

> *"The ability to troubleshoot makes it easier to identify mistakes & learn from them."*

Students also felt that the prototype helped *explain* the concept of arrays by allowing the students *visualise* concepts graphically

> *"...makes the purpose of arrays more obvious"*
> *"...it's easier to explain as I have used it"*
> *"...much better understanding of how elements are stored in an array"*

Students also felt that the prototype provided feedback *"clearly and accurately"* through an interface that was *"well designed and easy to use"*. They also felt that without the prototype they would have been *"trying to figure it out on paper"* and that *"...if we had just used the Java editor (Forte), I wouldn't have understood what was going on, this tool made it much clearer"*.

Some of the feedback suggested that the prototype could have been improved to provide better feedback or to include a demonstration by example. One student stated, *"...it only tells you there is an error but didn't tell you how to fix it or the solution to the problem"*. Students felt that the prototype was *"motivating"* and if it was made available on the Departments Intranet facility (Compweb) that they would use the prototype again, *"...because of its capability to make learning arrays easier"*

6. Conclusions

The aim of the study was to determine if an E-Learning prototype would make any significant contributions to novice students learning arrays in IT Tallaght. The results although tentative are as follows.

Prior to the survey, the group that did not have the prototype scored in performance an average of 8.5% more than the students who were given the prototype. After the controlled study, this group still scored more, this time an average of 7.6% greater. This implies that the group with the prototype very marginally closed the performance gap, but the percentages calculated are too marginal to attribute any "real" positive contribution to learning to the E-learning prototype. Therefore, the prototype in this study did not make any measurable quantitative impact in this particular study. However, where it did make a sizeable impact was in the qualitative study, which focused on the class who used the prototype and attempted to ascertain whether they saw any value in using the prototype as a learning tool. Based on feedback from these students, they felt more "engaged", "motivated", found it "easier to visualise arrays" and they "enjoyed" using the prototype as it provided an alternative approach to applying these concepts through repetition and gave instant visual feedback in response to Java code statements.

The primary but tentative conclusion that has been reached as a result of this study is that the prototype did not demonstrate any real measurable academic improvement in the student's knowledge or application of "Arrays in Java" but it did positively enrich the students learning experience. This warrants further investigation with a rationale to further develop a more advanced E-Learning prototype in this "Java Arrays" area, which will incorporate a more comprehensive instructional design methodology in its design and development.