

Teaching Java Programming using CABLE in a Collaborative Online Environment

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ABSTRACT

With the emergence and evolution of computer hardware, software and networks-virtual classrooms enable teachers and students to experience learning activities and to work together at a distance either directly or on a part-time basis. We are increasingly confronted with a need for 'lifelong training' and it is becoming increasingly difficult for us to attend physical classrooms on a full-time basis. Research to date has highlighted an area of interest with regard to teaching computer programming in an online environment. We investigate here the use of a Cognitive Apprenticeship-Based Learning Environment (CABLE) in the teaching of Java programming in an attempt to validate its effectiveness. This paper outlines the result of using a pedagogical model which employed a combination of instructional strategies including directive support, responsive cognitive apprenticeship, collaborative learning, stimulating metacognition (organising, motivating (through a "spark", modifying one's own skills), and using various technologies via the use of online discussion through Blackboard.

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1. INTRODUCTION

Learning outcomes are statements of what a student should know, understand or be able to do at the end of a learning activity and they describe how he or she is expected to demonstrate that achievement. In order to best adhere to the CABLE model, the learning outcomes needed to be specific in their design [1]. Learning outcomes should provide a broad description of the skills that the student will achieve during the e-tivity. If the learning outcomes are not indicative, this could obstruct individual or even innovative delivery of content by the tutor assigned to that module. It is necessary to draw upon an implementation so that an online course might be aware of competition, adaptable in approach, able to make a virtue of what is offered and is in a position to be flexible [2]. By being thrown into a collaborative, online environment of education, they (students) are forced to adapt to a new style of communication and productivity. This is first-hand experience that is invaluable as one progresses through their career [3]. This is particularly true for Java programmers where graduates are quite likely to be drafted in to Agile teams. Agile Development has proven to be effective at improving the performance of many software development teams. Their productivity has increased and become more predictable and their defect rates have fallen [4]. Many development processes attempt to take the human element out of software development, but Agile's main focus is about leveraging the people and their interactions. It can be concluded that good people, working in teams who build successful software products.

Building e-learning courses to reflect the real world is a good step away from pure information delivery and thus makes the course performance-based. The course should be as pragmatic as possible so that the learners can utilise the skills they are being taught. Developing e-tivities involves two primary areas of

concern. The first is content. The tutor should provide consistent and relevant content in a timely manner that also serves as a resource for future use. The second is context. How will the learner use the information in the real world? It is important to attempt to build an environment where the course extends beyond the computer, and engages the learner in the workplace with their manager and peers. An example of this is to have part of the course online and part as a facilitated team discussion [5].

2. TEACHING METHODOLOGIES

The use of group work is encouraged to promote communication skills, lifelong learning skills and independent learning. In group work, students can be assigned roles which reflect real-life situations. The key to successful group work is to ensure that members are dependent on each other for completion of the task. This is why the incorporation of a Google Doc activity was deemed appropriate. Including an aspect of peer assessment can prevent free riders, as well as awarding an individual mark to each student for their work. Overall the tutor decides the final mark and reserves the right to penalise the free rider by reducing the mark awarded to him/her. The use of learning logs/reflective diaries in which students record their experiences and reflections, forces the students to take personal responsibility and therefore promotes deeper learning [6]. This methodology is essential to lifelong learning. It is recommended to keep the group sizes small, around 3-5 students. The dynamics of the group selected by the lecturer should be based on academic achievement, personality, age, ethnic background and learning styles. This is not always easily achievable in an online learning environment.

The constructivism pedagogical approach has been an inspiration in the development of online modules [7]. Alternative methodologies have also been explored, including resource based learning, collaborative learning, problem based learning, narrative based learning and situated learning. Resource based learning is a viable methodology as students can see different viewpoints and appreciate the arguments in any given topic, and not just those given to them. It encourages students to be curious and questioning; it helps develop information skills, aids the promotion of active learning and also assists in maintaining the currency of a course. Collaborative learning is an approach that should promote active learning among the students, develop deeper appreciation and understanding of a given topic and will expose the students to different ideas relating to a module. Encouraging team-based collaborative activities as part of the teaching methodology will help instil these skills.

Question 18: Short Answer

What problems did you encounter in using this learning mode?

Sample of Answers

The main problem was getting started. I was not familiar with this type of interaction before and therefore not familiar with its operation, but I learned, so I could say that was a benefit really. I didn't participate in the group discussions every day, however now that I am more familiar with its workings; I probably would more often the next time.

The slides going too fast and slow. The quiz on day 3 gave problems too, I didn't know where I had gone wrong in the quiz, I felt if the correct answers were displayed afterwards it would have helped. It's difficult for groups to get together to discuss things, trying to coordinate a time when everyone can meet can be time consuming. I'd like some tips on improving my concentration. One problem I've found is that I can't concentrate when things get tough for me. Especially in OO Programming I had no problems using the learning mode. It was very interesting and it motivates me to do try and do well

The player for day three didn't work when I tried it, but other than that the module ran smoothly. I encountered no real problems and feel that if this was to be a distance learning experience with enough time allotted; it would be a very effective online course. Sometimes I found it hard to figure out the quiz. Enjoyed day 5 quiz the best.

Figure 1. Sample student responses

It is important to increase the student's responsibility. To this end a problem based learning approach where a lecturer gives a group a task/assignment without providing them with all the information required to solve the problem. Students are then encouraged to seek answers themselves and gain valuable confidence. Figure 1 outlines some student responses to online learning and one felt it would be advantageous to "encourage more of this type of learning". This correlates with CABLE's "responsive

cognitive apprenticeship". Giving students content for their module or topic is often a difficult task. Using Guest Lecturers from industry can certainly help a student to visualise a product or practice in the workplace. This 'narration' approach makes a subject more memorable, provides structure and makes a subject more interesting. In a collaborative online environment, this can be accomplished by providing information through other forms of media such as YouTube videos, expert interviews and providing a repository of additional reading material.

3. ASSESSMENT METHODOLOGIES

The assessment of learners is consistent. These procedures encompass an assessment schedule, learner feedback, assessment criteria, receipting assessments, late submissions and breaches of assessment regulations. First and foremost, assessment should be aligned to learning outcomes. Assessment measures the breadth and depth of learning. Final or summative assessment aims to sum up the learners' achievements. While on-going or formative assessment is used throughout the e-tivity to form judgements on whether and to what extent learning has been successful and to pinpoint difficulties so that remedial action can be taken. A sample comment from a student relating to this formative assessment technique was "*I enjoyed the tests the most because it showed me how much information I was actually taking in while reading the notes*".

While formative assessment encourages students to self-monitor and identify action necessary to achieve learning goals, summative assessment seeks to establish the level of achievement attained by the student. It is imperative that combinations of both methods of assessment are used. A collaborative task on the final day of the e-tivity using Google Docs was deemed to be the most appropriate approach. It was felt important that the coursework be kept to a level where it supports the learning process by consolidating skills and giving students the chance to apply them. Thus the aim is to keep the overall amount of work that a student has to do in any given task to complete their e-tivity to a reasonable level, evenly distributed over the course duration. In order to ensure that learning outcomes are achieved in both the practical and theoretical areas within a module, it was deemed necessary to include a special regulation in the course schedules for this e-tivity course. The regulation states that it is required that a learner who achieves less than 80% of the marks available in a module element, which in turn accounts for 100% or more of the overall module marks, should repeat the activity before progressing to new material. Assessment can take many forms with some of the key aspects/issues addressed below:

- the role of collaborative work in assessment and issues associated with rewarding group work
- the decrease in exam based assessment and the rise in the use of more project formats for courses
- the use of automatic assessment, thus providing instant feedback
- other types of assessment including use of the Web as a resource, peer assessment and the development of student key skills.

4. EFFECTIVENESS OF ONLINE LEARNING

One of the most fundamental aspects of computer lab exercises is that students engage with the process of learning new technologies. These new technological skills help aid students in their goal to work in teams. By becoming active members of teams, students learn how to design, plan and build challenging projects and assignments [8]. Working together means the group can reach an understanding of the requirements in a much more efficient and coherent manner. The process of communication means that each group member will learn what part they play in the team and as a result can encourage each other to identify and nurture individual skills [8]. It is evident that planning a successful educational framework within IT requires certain elements to be addressed effectively. Three strands identified are: technological practice, knowledge and nature [9]. With regard to technological practice within a computer programming environment, this entails students reviewing relevant code and/or implementing this knowledge through practical tasks using relevant software development tools. The technological knowledge itself should be generic and broad. So the students can have knowledge in as many different areas of their discipline as possible. Students should be encouraged to research and develop in areas that are not necessarily taught directly in the curriculum. Finally, the nature strand refers to the students' abilities to relate technology to and differentiate technology from human life [9]. This in turn provides students with invaluable skills before entering the workforce such as team work.

The need for students to interact in a virtual way is becoming more and more important. Articulate enables Flash-based presentations/e-learning courses to be rapidly developed from PowerPoint files. It can allow an e-moderator to develop and deliver content quickly and allows the distribution of the material in a format most people can view. Utilising tools such as Articulate can help enhance the learning environment. Articulate embeds itself into PowerPoint and allows a lecturer to develop quizzes, surveys and assessments as

well as delivering video, audio and other types of media in a structured environment. The product is ideally suited to users of Blackboard because the interactive material runs within Blackboard. Using environments such as this helps to focus students and encourage interactivity within teams. A weakness often identified is an unwillingness to embrace change, whether that takes the form of adopting a new teaching methodology or adopting some new technologies as teaching aids. Perhaps students should be more actively involved in determining how a module gets delivered. There are 6 critical steps to achieving collaboration: collaboration itself, communication, content, critical thinking, creative innovation and confidence [10]. Ensuring that students can achieve these goals throughout their e-tivity is crucial.

In order to assess the effectiveness of online learning through the chosen e-tivity, three data sources were used, (1) the responses to the questionnaire questions 12 – 17 administered only during the cognitive apprenticeship based treatment, (2) responses from personal student interviews, conducted in days 2 and weeks 5 of the study, and (3) an analysis of products, processes and perceptions based on the Triple Framework approach for evaluating online environments [2]. Questionnaire questions and interviews with students focused on four main issues:

- (a) The effectiveness of email for feedback
- (b) The effectiveness of online notes on class website
- (c) The usefulness of posting sample test solutions online
- (d) Whether students like working in groups

"Another very important aspect of learning to program is to learn from each other and work as a team. In the traditional programming class, it is common that students are assigned to work on a team project" [11]. It is vital to have the students work together on a collaborate activity and for the tutor (e-moderator) to respond quickly to emails and discussion questions from students. This concept fits with the CABLE approach. This is validated with a quotation from a student as follows, "uploading a piece of code was also useful because you see from other students' work where you might have gone wrong. Overall I believe it's a positive approach to learning and it would be even more beneficial to students if more were to get involved. I think it is an effective form of learning". Wang also describes how teaching Java online should begin with outlining the importance of learning Java in the first place – to put it in context. This formed part of the rationale made available to students as can be seen in Figure 2.

Java Programming 1st Year BSc in Computing with Security & Digital Forensics	Student Name: XXXXX
	Year Group: CSDF
	Date: Day One, 23 rd April 2012
	Duration: 20 minutes – max of 60 minutes
Topic: <i>Object Orientation Concepts – Java Arrays</i>	
Aims: To become knowledgeable and efficient at declaring and initialising arrays.	
Learning Outcomes: (a) The student will define what an array is, how it is declared and how it can be initialised.	
Spark: There are times when a programmer wants to work with groups or sequences of values. Read the material for Day One, then try and 'beat the clock'! When you are successful, post the code required (in your discussion area) to declare a String array to hold 7 elements.	
Discussion & Reflection: As a group, discuss areas where arrays might be used in a real world scenario. Are they secure?	
Resources: Laptop or desktop machine, Broadband internet access, Email access, Microsoft Office, Ability to play shockwave files	
Activities	Read and review the Articulate presentation in the Day One content folder.
1	Play the YouTube Video associated with Arrays.
2	Complete the assessment as part of the Articulate presentation with a grade $\geq 80\%$
3	Post a code snippet in the relevant discussion area with a brief reflection on the material.

Figure 2. Student Lesson Plans

The concept of Embodied Cognition implies that effective learning occurs in an environment that is dynamic and that includes/facilitates interaction and manipulation. In essence, students learn by doing. This provided the rationale for adopting a CABLE approach that incorporated Articulate – which offered the students some ‘Learning Engagements’ to help re-emphasise knowledge. It can also be noted that brain science is proving that our sense of the body extends to the tools we utilise. This infers that when students produce an action through a mouse or a gestural interface, it can correspond to performing that action in the real world. These interactions act as a powerful element in improving cognitive performance and help us make sense of our surroundings [12].

5. EVALUATION & PARTICIPATION

Salmon’s 5 stage model outlines key criteria for designing and implementing an appropriate e-tivity [13].

- Stage 1 outlines the importance of “Access and motivation” where the e-moderator welcomes the students and uses positive language in order to encourage active participation.
- Stage 2 encompasses a sense of “Socialization”. The use of discussion forums as a method of getting to know the students and introducing oneself and the various groups to each other. Encouraging the students to reply to each other and congratulate and/or commend each other is a positive step in this direction.
- Stage 3 relates to “Information Exchange”. This was achieved by updating material on an ad hoc basis as a result of encouraging feedback from students. This action demonstrated the level to which the students were interacting with the material and it also demonstrated the willingness from the e-moderator to improve material thus acknowledging the students’ input.
- Stage 4, “Knowledge Construction”. The Articulate presentations were interspersed with ‘Learning Engagements’ which facilitated this stage. Feedback from the students (both positive and negative) showed a marked increase in evidence of knowledge gained. This was achieved through quizzes, surveys and various learning engagements which culminated in a collaborative piece of work using Google Docs.
- Stage 5, “Development”. Synthesis was evident through the use of the Frequently Asked Questions section provided, the YouTube videos and extra material/suggestions made by both the students and e-moderator. The extra material would serve as an excellent starting point for future reflection and is evidence of how the students evolved to taking ownership for their learning.

In order to best serve Salmon’s model, the lesson plans had learning outcomes written in accordance with Bloom’s Taxonomy.



Figure 3. Bloom’s Taxonomy [14]

The use of particular verbs in the learning outcomes steer the lessons towards synthesis and evaluation. Table 1 outlines the learning outcomes and relates the verbs to the relevant tier of Bloom’s Taxonomy.

As e-moderator it is necessary to be confident in one’s approach, to be constructive, facilitating, provide a developmental environment, to share knowledge/experience and to be creative in delivery and assessment strategies. It is the author’s opinion that these goals were achieved. When the students were asked to provide feedback to the following statement, “*I felt the lecturer notes and exercises improved my understanding of the subject*”, 86% “Strongly Agreed” with the remainder “Agreeing”. The initial invitation to join the e-tivity was to a first year Computer Security and Digital Forensic class who are normally taught

in a Face-to-Face (F2F) environment. 25 students in total are in the group with 8 mature students (over 23 years of age). It is interesting to note that the entire “mature student” group agreed to participate while the remaining students (aged between 17 and 21) ignored the invitation without explanation. Is it possible that COL is mainly suited to the mature learner? Do e-learners need to be self-motivated and have extra determination in order to succeed? Verbal conversations with some of those who accepted the invitation cited a lack of motivation among the younger students and an assumption that they would have to do “extra work”. Upon reflection perhaps additional mechanisms could have been introduced as encouragement/incentives. Perhaps naively it was assumed that computing students who have grown up in the information technology age would jump at the opportunity to learn their discipline online.

Table 1. Relating the Learning Outcomes to Bloom’s Taxonomy

Day	Learning Outcome	Verb(s)	Bloom
Day 1	The student will define what an array is, how it is declared and how it can be initialised.	define	Knowledge
Day 2	The student will explain and indicate how to label, access and iterate through an array and an array of objects.	explain	Comprehension
Day 3	The student will demonstrate and illustrate applied cognition by examining code samples and identifying errors.	demonstrate, illustrate	Application
Day 4	The student will analyse and formulate object oriented concepts relating to Strings and create appropriate code samples.	analyse, formulate	Analysis
Day 5	The student will evaluate and appraise the benefits of StringTokenizer culminating in a group collaborative effort in design a functioning piece of object oriented code.	evaluate, appraise	Synthesis & Evaluation

The screenshot displays a web-based email interface. At the top, there are 'Message Actions' and 'Collect' buttons. Below this is a list of messages with checkboxes and links to 'Reflection', 'RE: Reflection', and 'RE: Reflection'. The selected message is from Nigel McKelvey, dated 12/04/12 15:03. Below the list, there are 'Select: All None' and 'Message Actions' buttons.

The detailed view of the selected message shows the following information:

- Subject:** RE: Reflection
- Author:** Nigel McKelvey
- Posted Date:** Tuesday, 24 April 2012 21:53:38 o'clock BST
- Edited Date:** Tuesday, 24 April 2012 21:53:38 o'clock BST
- Total views:** 11 (Your views: 4)

The main content of the message is a reflection post:

first year programming at LYIT certainly gives you the grounding to move forward with OOP. As the years progress, you will build on what you have covered in 1st year....you are currently doing ArrayLists....I'm also teaching ArrayLists to 3rd years - but taking it from a different angle - so you move away from 'learning code' towards applying code properly and 'evaluating' different ways of implementing appropriate code.

By the end of your second semester in first year you have covered a lot of OO in Java. You will be moving on to GUI and Swing programming in Java next year - which is more about creating "pretty" user friendly applications. So you will get to see visually what your code can do.

Hope this helps answers your questions. I can't stress enough how important it is to sit, study, learn and understand Java in 1st year....it will save you a lot of time in subsequent years.

Figure 4. Student Reflections

Salmon [13] identified several traits of activity when it comes to e-tivities. Analysis of the forums within Blackboard revealed that 3 of the 7 participants were 'squirrels, 1 'mole', 1 'elephant', 1 'rabbit' and 1 'mouse'. The 'squirrels' logged on irregularly and did several tasks in one sitting. It was helpful in some ways as it provided the e-moderator with feedback relating to a day's content before the content was technically due to be delivered. Therefore issues were almost pre-empted. The 'mouse' logged in once at the beginning of the week, carried out some tasks and sent several e-mails throughout the week. This individual seemed more comfortable with e-mailing the facilitator directly rather than engaging with others through discussions (directive support). Prompt responses from the e-moderator seemed to satisfy the requirements. The 'mole' left some random messages that indicated a lack of understanding on occasions. This student was directed to communicate with the 'elephant' and 'rabbit' for peer support and guidance. This also provided the 'rabbit' with an additional role that would satisfy their love for being online (stimulating metacognition). It is evident from Figurewhere it can be seen that the Reflection discussion forum received 716 hits in just 5 days, that COL is certainly a positive outlet for teaching programming.

6. CONCLUSIONS

In the author's opinion, there was evidence of strong social presence, teaching presence and cognitive presence with this e-tivity as can be seen from the responses to the survey. Upon reflection, there are areas where improvements could be made such as: improved initial invitation to encourage those who (for this e-tivity) did not participate, clearer instructions for carrying out the mini-assessments and introducing a smaller collaborative piece of work earlier in the week (almost as a trial run) for the main event on the final day (Google Docs). The activities concluded with the students updating a document which was uploaded to Google Docs and permissions to edit were assigned to the students participating. It is clear from the survey that the students had a positive attitude towards the learning environment and there is positive evidence for the effectiveness of online learning which validates the use of the CABLE approach for this e-tivity. The high volume of messages demonstrated a clear sense of collaboration between the students and their eagerness to participate in the Google Docs activity supports this. Reflection has led to conclusions that the learning engagements could have provided clearer instruction but one student commented to the effect that having to re-do the tests reinforced the material – so it wasn't a wasted exercise. This reaffirms the importance of the Triple Framework approach for the online evaluation. There was also a marked increase in activity from user on days 3 and 4. Perhaps this would have been the ideal time to engage the students in a collaborative exercise rather than waiting until the final day when activity tailed off. In saying that, the exercise has proven to be successful and a worthwhile task for both the e-moderator and the students.

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