The application of contemporary teaching approaches to teaching a course in *Java Programming Language*

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Abstract

Java Programming Language is an elective course presented to senior students majoring in disciplines other than computer science and technology at Jilin University. The course aims to introduce object-oriented computer programming and to develop students' skills so that they become competent programmers able to work independently on completion of the unit. This paper will indicate how contemporary teaching approaches and strategies such as problem-based learning (PBL) and concept mapping could be used in this course to complement conventional teaching methods. An example of PBL applied to teaching *Java* programming is given and the potential impacts of introducing these contemporary teaching approaches is discussed and analysed.

Introduction

Until relatively recently, instructional methods used by university lecturers were teacher-centred and tended to utilise a relatively narrow range of teaching strategies. Gradually, at different rates and at some institutions more than others, a variety of teaching strategies have been introduced into universities since the early-1970s; particularly in European and North-American universities. A common characteristic of these methods is their focus on student-centred learning with the main goals of teaching being the cultivation of an active, deep-learning approach and the provision of life-long learning skills rather than indoctrination of knowledge within passively-receiving students. Modern graduates are expected to possess a number of generic attributes such as the ability to solve problems, the ability to work well in groups, realistic self-evaluation, an independent approach to learning, and so on. Educational researchers identified and formalised definitions for different approaches to, strategies within and techniques applied in teaching and learning so that terms like behaviourism, development and constructiveness, 'concept mapping', 'problem-based learning', and 'case study', came into being and have been used in many disciplines including computer science. This paper will explore several of these concepts in the context of my involvement in teaching a non-specialist unit in programming and the changes I seek to implement to improve learning and understanding of the students who will take it in the future.

According to the curriculum of Jilin University, *Java Programming Language* is an elective course for senior students whose major is not computer science and technology. These students should have some background in the foundations of information technology and computer programming. The class size is usually about 60 to 80 students who take eleven, two hour lecture sessions and four, two hour laboratory practical sessions. Their previous experience of programming is process-oriented programming which uses approaches derived from a distinctly different ideology to the one guiding the object-oriented programming techniques used in *Java*. Students come into the unit with different abilities in, and experiences of, program design as well as being required to come to terms with this different programming philosophy. If students were to be taught in a conventional way which emphasises on teacher-centred lecturing and focus of their learning efforts driven by the needs of the traditional assessment timetable (with performance in assignments laboratory performance and final examination dominating the students efforts) it is likely they will learn in a superficial, dependent and passive way. According to student feedback, most of them can not really use this language in practice – which is a commonly reported response for programming language units in general. For students, the aim of learning a programming language is clear, they should be able to design functional software when they have completed this course; *Java* is an excellent language for the design of web-based, online software applications that is widely used by Information and Communication Technologies professionals; so there are good and obvious,

motivating reasons for students to complete the unit and become competent *Java* programmers. Furthermore, there is a real thrill and sense of achievement when they design their own software that can be used in the real world. But the process of learning this material and developing the necessary skills in the conventional way is boring. Integration of a combination of contemporary teaching approaches such as PBL, and the provision of interesting case study examples with traditional teaching methods could improve students learning by helping them to become active, independent and open minded learners, ultimately encouraging them to become life-long learners as well as helping them to become competent, successful programmers.

Applying PBL to teaching *Java* programming

Introduction of PBL

The guiding principle of PBL is to use problems, queries or puzzles as a starting point for learning. In fact, it is probably better to view PBL as a continuum of approaches rather than a single method or technique. It could include various proportions of lecture-based teaching with many small problems to a large stand-alone problem with almost no classroom teaching or traditional assessment by the teachers, the important characteristic is the inclusion of open-ended problems based in the day-to-day practice of the discipline, which are aimed at simultaneously developing and integrating higher order thinking, with discipline-specific knowledge and practical skills.

Students greatly benefit from PBL. Firstly it can promote student motivation as it helps 'students to become more engaged in learning because they are hard wired to respond to dissonance and because they feel they are empowered to have an impact on the outcome of an investigation'. Secondly it offers students 'an obvious answer to the questions, "Why do we need to learn this?" and "What does what I am doing in school have to do with anything in the real world?"' Thirdly 'the ill-structured problem scenario calls forth critical and creative thinking by suspending the guessing game of, "What's the right answer the teacher wants me to find?"' The most important point is that students can learn how to learn when they engage in PBL. PBL 'promotes metacognition and self-regulated learning by asking students to generate their own strategies for problem definition, information gathering, data-analysis, hypothesis-building and testing, and comparing these strategies against, and sharing them with, other students' and mentors' strategies'. (Illinois Mathematics and Science Academy)

Characteristically PBL:

- is context-based and uses 'real-life' situations;
- focuses on thinking skills (problem solving, analysis, decision making, critical thinking);
- requires the integration of inter-disciplinary knowledge/skills/behaviours;
- is self-directed and develops lifelong learning skills; and
- is commonly undertaken by small groups with individual tasks shared out between the members of the group.

Expectations on students learning *Java*

It is our opinion that the greatest difficulty students have when doing the course *Java Programming Language* arises from the difference in programming ideology. Previously most will have had experience with the *C* programming language. While there are some similarities as there are some common terms and expressions in *C* and *Java*, *C* is process-oriented and *Java* is object-oriented and the course initiates the student into the core concepts and methods of object-oriented computer programming. The educational objective of the course is the development of students' skills which include the specific programming related skills of elicitation and analysis, design and programming, and testing, as well as the generic skills of team-building and collaboration with others in a group. Learning a programming language requires that learning should not focused on a set of isolated, individual practical problems. And it is a day-to-day fact of professional life that programmers must work in a group; most projects are much too large for only one person to complete. This requires individuals to work within a team to investigate and study relevant knowledge such as project management, software engineering, network security and network programming. Each student documents their individual journey of discovery in the form of a reflective journal in which they note facts, opinions and detailed considerations, as shown in Figure 1.

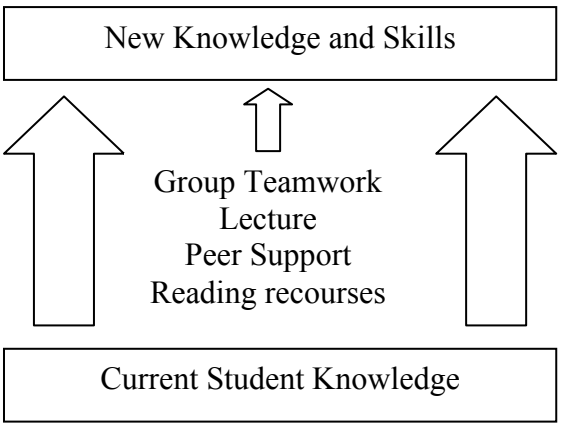

Figure 1. Students build on their existing knowledge by being challenged by new teamwork activity

An example of PBL in *Java* teaching

Dull teaching methods combined with limited laboratory time means that it would be difficult for students to complete the demanding task of mastering this language. Instead, by using the PBL approach students will learn how to collaborate with others in the group and have a proper motivation for learning how to program in *Java*. While the students taking the unit are non-specialists they generally advanced students so they should be capable of dealing with more open-ended and ill-structured problems that are typical of real-life. In order to trigger students' interest of learning, we should present them with an interesting

problem. A possible example is outlined below, it is envisioned to be a six-week project.

The problem

There are many computer games today most of which are not designed for little children. My son is only 3 years old. I would like to introduce an interesting game appropriate to boys in his age group. You are required to design and implement a Cat-and-Mouse Game for a 3 year old boy. This game contains a board with many grids where a cat is chasing a mouse. Some of the grids on the board are 'wall/obstacle' objects on which the cat/mouse is not allowed to step on. The cat and the mouse take turns to move and each move is only allowed to be in a single step. Each step can be up, down, left, or right; but no diagonal movement is allowed. If the cat jumps on the mouse, the cat wins. If the mouse reaches the exit point on the board, the mouse can escape from the cat; in that case, the mouse wins.

In addition the game:

- should present an engaging interface that young children respond well to;
- be easy to use and easy to learn;
- have good aesthetic appeal; and
- be playable in an internet environment.

Proper, high-quality multimedia components or attributes are encouraged (these could include all or some of audio, video and images).

Objectives of the project

Students may need to do some research about the children of this age group: what they respond to, their abilities etc. There is no one perfect answer, plus the problem is a real-world kind a professional would be faced with, which should excite and challenge the students who will have the opportunity to use their own imagination and creativity to design a game which can be played by children. Their prior knowledge is not sufficient to solve the problem, which will make it necessary for them to collect and absorb new information, techniques and recourses. They will also have to work as part of a team in which they divide work and collaborate in groups.

Objectives of this project are to:

- learn to work effectively in a collaborative endeavour;
- learn techniques of investigation and self-directed learning;
- experience working in collaboration with a group;
- learn skills necessary for working collaboratively;
- gain specific knowledge and skills;
- apply skills and knowledge learned to solve a real problem; and
- apply skills and knowledge elsewhere to solve a problem.

Logistics and practicalities (How will I get this to work?)

The problem should be given at the beginning of the semester. Students would firstly get interested in the problem. They can design the game out of their own imagination according to the requirements given above.

Students in the project

Students are placed into groups with the constraints of maintaining a group size of five to seven students and a gender balance within the group. These group formations last for one semester. The problem triggers discussion about programming and therefore triggers the learning process. In discussions students will brainstorm for a while to make it clear what they already know about programming and what they still need to learn to engage effectively and understand with the problem – and identify where the gaps are in their knowledge. After brainstorming, students set learning goals for themselves, which is followed by self-directed learning. During the self-directed learning each student works to meet the agreed learning goals. They can use whatever learning method they wish. Thereafter the group meets again where the students discuss what they have learned. They try to make a synthesis of all the knowledge they have gained and thus try to better understand the problem. Students will be assisted by us as they complete the following various steps as they work through the project:

- analysing the problem;
- defining the problem;
- setting objectives;
- collecting information;
- employing methodology;
- program development; and
- summarising and reflecting.

Teachers in the project

Teachers present problem and related recourses before all lectures. Several tutors are chosen from senior students to present at group meetings to help students. However, their role is rather as a facilitator and a domain expert than a teacher. The tutor is not expected to lecture or teach but facilitate group meetings, for example, by asking questions/ comments that give students fruitful directions to work towards.

Ways of acquiring information

Because of the complexity of a real-world problem, it could be solved in one of many different ways. Students may need to list the appropriate techniques and approaches that they have already learned, need to acquire, as they divide the requirements of their problem into discrete pieces. Much of the information they might require to attack their problem can be obtained in many ways such as library and internet searches or consulting with experts for advice.

Demonstration of the final learning product

Students are asked to do an oral presentation and a report for each group at the end of the project. The presentation should not be simply a repeat of the project report. They may demonstrate their game and deal with some key issues mentioned above.

Timetable

The project does not last for the whole semester as extra time is given to reflect and reconsider what they have

learned and what/how they should learn in the future. A timetable for one semester in detail is given in Table 1.

Table 1. Timetable for one semester

Week1	Organising group, setting the problem ,lectures, group meeting
Week2	Group meeting ,lectures
Week3	Lectures, laboratories, group meeting
Week4	Mid-semester examination, lectures, group meeting
Week5	Lectures, laboratories, group meeting
Week6	Report, presentation, oral examination
Week7	Lectures, laboratories
Week8	Lectures, laboratories

Assessment

What do we want to do with this? The basis and thrust of formative assessment has not been understood. The design presented is for a more evenly weighted program of continual assessment. The same misconception was presented by Wu (2006) but was much easier to deal with as it was less detailed.

There are many kinds of assessment such as summative assessment, continual assessment, formative assessment, peer assessment and self assessment, etc. A conventional breakdown of assessment tasks consists of 30% continual work and 70% final examination marks. This is a summative assessment model focused on a final assessment that probably encourages students to take a superficial learning approach. By contrast, formative assessment is often done at the beginning of and during a program, thus providing the opportunity for immediate evidence of student learning in a particular course or at a particular point in a program. Self assessment and peer assessment involves students taking responsibility for monitoring and making judgments which get more thorough and deeper levels of cognitive results and assist students in thinking more critically. Thus a combination of formative assessment and peer assessment can be adopted in *Java* teaching. An assessment according to three aspects including process, product and individual knowledge or skills is given in Table 2.

Table 2. Assessment in java teaching

Classification	Score
Peer assessment	5
Mid-semester examination	10
Project report	30
Group presentation	10
Oral examination	20
Final examination	20
Attendance	5

Need for better communication between students and teachers

Less communication between students and teachers leads to less feedback and understanding of each other, especially for large classes of first year students. Most of the students are too shy to ask questions in the class, and even after the class there are few students who will ask questions. It is difficult for the teachers to get to know the students very well and to find out how they are doing.

Peer assessment and mid-semester examination give an assessment in the process of a semester's education, while project report and group presentation giving on product and oral examination and final examination on individual knowledge. Then we get a general feedback on students' learning efficiency.

Application of concept mapping

Concept mapping is a tool for assisting and enhancing many of the types of thinking and learning that students should undertake during their university studies. One way of creating a concept map, is to write the main idea in the centre of the page (which may be a word, a phrase, or a couple of juxtaposed ideas) and then place related ideas on branches that radiate from this central idea (Lanzing 1997).

Concept mapping is useful for a number of reasons and can be undertaken for several purposes, for example:

- to generate ideas (brain storming, etc.);
- to design a complex structure (long texts, hypermedia, large web sites, etc.);
- to communicate complex ideas;
- to aid learning by explicitly integrating new and old knowledge; and
- to assess understanding or diagnose misunderstanding.

In this project, the related concepts that students need to understand and relate to one another could be given in a concept map shown in Figure 2. *Java* programs integrate several main components; Applets, Graphical User Interfaces, Threads, I/O Streams, Java Database Connectivity (JDBC) and Networks. Being an object oriented programming language, two important concepts that students must fully understand are class and object. Students must understand their relationship and characteristics of class, which are inherit and polymorphism. In addition, package, interface and exception are other important concepts which are also particular features in *Java* students must know and learn to use.

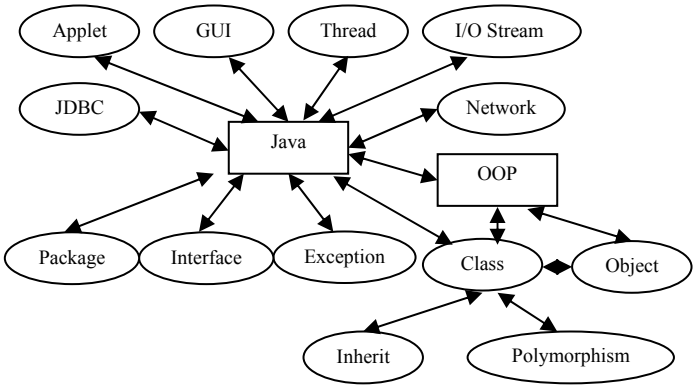

Figure 2. A concept map showing the relationships of *Java*'s main components

Analysis and discussion

PBL and 'concept mapping' could both be used very effectively to improve teach teaching approaches in *Java Programming Language* although they should probably not be used doctrinally as a dominating philosophy of teaching. It would seem that PBL is a good teaching method which can challenge students to 'learn to learn', and I have observed it being used successfully in the School of Information Technologies at The University of Sydney. Some students do find it hard to learn in this way. I think that, first-year students could find it particularly difficult as their prior knowledge in computer science is limited and probably insufficient to allow them to even begin to solve problems dependent on some minimum level of programming competence. If such students were to be given a problem requiring the acquisition of detailed 'brand-new knowledge' and several complex skills before they were able to produce a workable solution it is not likely that they would succeed and meet the teachers expectations. On the other hand, if PBL was to be used with senior advanced it is much more likely that these students would be successful and that they would have a worthwhile learning experience.

'Concept mapping', is a useful technique for representing knowledge graphically, though should also be used carefully. It is meaningful when complex information is being interpreted in visual formats – although I think that there will be cases where some groups of information and ideas may not be all that well-suited to being considered in this way e.g. by trying to use a particular map for different cases. Teachers probably do not need to try to develop a concept map for everything and all the concepts dealt with in class. This might become be a waste of time and possibly make it harder for students to understand the course. Even if it was a very excellent concept map that enabled students to remember the material for much longer than if they simply take notes from texts. A good concept map should help with the assimilation of new concepts and propositions into existing cognitive structures, and be clear and logical but not rigid in structure, so that, it allows future information or viewpoints to be included (which can help students absorb and adapt new information and ideas). A bad concept map with vague illogical structure and no connection with prior knowledge would make students more confused.

All teaching methods have their own specific advantages and disadvantages. For example, let us compare contemporary teaching methods with traditional teaching methods. The former attaches high importance to students' involvement in learning, which we call 'deep learning', while the latter focuses more on teacher teaching and student listening. Two of them are differentiated as student-centred and teacher-centred. For some students, for instance, first year students, it could be better if they are taught with combination of both methods as some contemporary teaching strategies may be too difficult to employ with large first-year classes; or be so different from their previous experience that the students find them too challenging. In contrast, contemporary teaching methods are advocated for senior or advanced students as these students will be more able to cope with the challenge, understand what they are learning and get fully involved in it.

In regard to the teaching of the unit *Java Programming Language* at our university, we need to work with the fact that the senior students have already learned about *C* programming. They are familiar with many similar expressions that are used by both *Java* and *C* and should have some programming design skills. These students would benefit from PBL – a real-world task which they can focus on from the beginning of the semester. With the assistance of these other contemporary strategies such as 'concept mapping', case study examination combined with traditional lectures, laboratory practical sessions, assignments and examination, their learning efficiency will be high and their success more certain.

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