TEACHING STRATEGIES AND METHODS IN MODERN ENVIRONMENTS FOR LEARNING OF PROGRAMMING

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ABSTRACT

This paper presents teaching strategies and methods, applicable in modern blended environments for learning of programming. Given the fact that the manner of applying teaching strategies always depends on the specific requirements of a certain area of learning, the paper outlines the basic principles of teaching in programming courses, as well as the possibilities for applying modern teaching strategies in this area. Blended learning of programming is gaining dominance in higher education, through combining traditional and modern technologies and teaching methodologies in classroom and via the internet: in traditional courses – with lessons in the classroom and regular additional forms of teaching via the Internet and in distance courses - with regular lessons and additional forms of teaching in the classroom / via the internet. This paper describes teaching strategies which are implemented within the blended programming traditional and distance courses in the School of Electrical and Computer Engineering of Applied Studies in Belgrade: Programming fundamentals, Programming languages and Object oriented design. The methods recommended for carrying out teaching strategies in this area have been described: modernized teaching strategies and the increasingly popular strategies of collaborative, situated and self-directed learning. Considering all the above, this paper can in fact motivate teachers in the given area to improve their teaching and adjust it to modern generations of students.

1. INTRODUCTION

Development and use of internet have made significant changes in education. The very beginning of this century is considered as a breakthrough in higher education, as there have been significant transformations in teaching approach as well as teaching strategies and methods. Now there are final solutions of modern blended learning environments, which include teaching and learning via the internet in many different forms (without terminating traditional learning in classroom), as well as new teaching methodologies and technologies (without dismissing those previously developed and rather modernizing them). Because that, methodology of teaching does not represent a package of "ready-to-wear" recipes, as was the case with traditional learning environments, but has a rather flexible basis for the development of the existing and finding new methods of modern teaching strategies.

In the area of programming as well, teaching methodology is being constantly improved and combines different methods of applied strategies. The reasons for this can easily be found in the basics of learning in this area: learning of programming includes learning the theory in the form of basic elements and programme algorithms, as well as a practical part in the form of mastering the skill of using modern environment for the sake of program development and the logic programming through as many different problems as possible in the chosen programming method and language. In the very beginning of your programming learning, you can benefit greatly from standard surrounding libraries of program development and already solved problems in various textbooks and other similar teaching materials, as well as discussions with teachers considering the way of solving problems. As far as further development is concerned, individual and team program solving with the help of developing surroundings and tools is the best way to go.

In this paper, there is an overview of applied a modern teaching strategies and methods in learning of programming in blended courses: Programming fundamentals, Programming languages and Object oriented design, in the School of Electrical and Computer Engineering of Applied Studies in Belgrade, which

constantly follows and applies advances in education. Mentioned courses are developing in this School, in classical and distance studies since 2012/13 academic year.

Simultaneously, this paper touches current questions in higher education, such as: How do you keep traditional methods and strategies that are proven to be efficient, but at the same time introduce new ones, supported by modern technologies and which are of great importance to new generations of students? How do you enable students to be active in certain segments of lessons and not just passive observers? How do you obtain and maintain the collaborative teacher-student relationship?

2. TEACHING STRATEGIES - FROM TRADITIONAL TO MODERN

If we consider teaching strategies in modern learning environments, we cannot generalize when it comes to advantages of ones over the others, nor when it comes to strategies and their methods which are unchangeable. For developing highly efficient learning environments in any area, depending on the specific requirements and available experience of the already developed environments, it is necessary to choose teaching strategies, and after this gradually implement all the acquired experience with the applied strategies into their further development.

Teaching strategies in modern blended learning environments [Petrina, 2007] are student-oriented: The structure of learning environment is totally adjusted to students; The process of teaching is fully directed to students; During the teaching, the students are encouraged not only to take in information, but do more research, critically contemplate on the teaching material, perform individual or team work on solving specific problems they encounter during teaching; Both teachers and students are simultaneously encouraged to continuously, during the process of teaching and learning, act as a team which cooperates in this process [Hart, 2014].

To make a suitable choice of strategies in a certain area, it is first of all necessary to study general characteristics of specific actual teaching strategies [Bullen, Janes, 2007]:

- Direct Instruction Strategy – implies learning from the previously defined content of the teaching material, prepared by the teacher. The traditional direct instruction strategy mostly involved a passive absorption of the content by the students, while with modern forms of the same strategy, a constant student activity in the process of teaching and learning is implied, due to the existence of internet platforms which stimulate active learning, and interactive content of the teaching material [Ruth, 2008].

- Collaborative Learning Strategy – means learning through communication on the teaching material between teacher and students and among students themselves, as well as an active student teamwork on problems and projects, or simply put - a cooperation between teachers and students in the process of learning, a live one, but also with the help of different modern web tools for communication and online teamwork. With modern forms of this strategy, the process of teaching is rather adjusted to individual students.

- Situated Learning Strategy – means learning through practical problem solving, practical exercises, experiments, seminar papers and projects, all accompanied by the instructions and help of the teachers, and supported by a wide spectrum of web and multimedia technologies, animations and simulations in virtual labs. Modern forms of this strategy enable a rather active participation of students in the process of teaching.

- Self-directed Learning Strategy – means learning from the teaching material, as little as possible recommended by the teacher, and as much as possible researched by the students themselves. Earlier forms of this strategy involved researching of the printed material, and its modern forms also require browsing the material on internet platforms for learning, web pages, wikis, blogs and social networks. This strategy is characterised by active student involvement, and the process of teaching adjusted to their individual needs.

Each modern teaching strategy requires a special approach to teaching, and specific forms of teaching organisation, as shown in Table 1.

Table 1. Basic characteristics of modern teaching strategies

Teaching strategy	Approach to teaching	Forms of organising teaching
Direct Instruction	Learning Transmission	Working on presenting the content
Collaborative Learning	Learning in Society	Working on preparing cooperation in learning
Situated Learning	Learning Environment	Working on preparing practical work in learning
Self-directed Learning	Learning through Research	Working on preparing for research in learning

There is no universal recipe for choosing a teaching strategy and method in blended learning environment. Experience shows [Bonk, Graham, 2006.] that choosing the right blended model presents a very important step there. If a model is well chosen there are conditions for its implementation - with the use of appropriate strategies and methods - to give the expected results. Experiences also show that the choice of strategy and method, which is made according to the instructional design for every particular blended model, is just a guideline for the further development of teaching activities. Encouraging active student participation in teaching, continuous communications and cooperation between teacher and students, provide outlines and within them teachers' and students' activities are further formed.

This paper further presents experiences in the choice and use of teaching strategies and methods in developed and implemented blended learning environment for teaching of programming in the School of Electrical and Computer Engineering of Applied Studies in Belgrade:

- in classical studies – with the initially applied basic blended learning environment model, along with the advanced blended learning model, from school year 2006/7;
- in distance studies – with the advanced blended learning environment model from school year 2012/13.

3. MODERN ENVIRONMENTS FOR PROGRAMMING COURSES

When selecting the teaching strategies which will be used in a specific area through their methods, it is, at very start, necessary to take into account the specificity of the area in question and basic principles of teaching in this area. The coming section of this paper gives a brief overview of the basic principles of teaching in programming courses.

3.1 Basic Principles of Teaching and Contents Specifics in Programming Courses

Modern learning environments for programming [Djenic, Krneta and Mitic, 2011], [Hadjerrouit, 2007], [Hadjerrouit, 2008] are constantly improved so they would be more efficient, but at the same time, they use basic principles of teaching programming, which are given below:

- Teaching theory is a guideline for praxis - although it goes without saying that every programming language can be learned best through praxis, the best "guide" for it, just like in all the other areas, is theory. Teaching theory here implies learning the syntax, definitions of certain groups of programme elements, the manner of connecting these elements, algorithms and methods of their application in programmes;
- Practical teaching is crucial – a programming is mainly learned through practical work on the programmes. Practical teaching in this area involves giving instructions and help in solving problems in a specific programming language, initially based on the examples of solved programmes in the same language, and later in finding original solutions for diverse problems of programme tasks, within exercises and projects;
- The principle of connection between theory and praxis – the theory of programming is a precondition for practical work in this area, since it is essential that students adopt it before beginning with the analysis of the completed programme solutions. On the other hand, practical work on programme tasks may serve to students to better grasp the theory and check the importance of theoretical knowledge;
- The principle of availability - to prevent certain concepts in the area of programming from being abstract, their descriptions should be clear and available - adjusted to students and based on the pre-knowledge expected from them. When teaching any programming language, it is necessary to explain them. In modern conditions, this is considerably supported by multimedia;
- The principle of active student role – in learning of programming, the priority has always been in the active role of students. Students are expected to show initiative, work individually or in teams on problem solving, ask questions in order to clarify certain situations they encounter in problem solving, and participate in discussions on the teaching material with teachers. In all this, web tools are used quite efficiently;
- Principle of interaction - student-teacher, student-student and student-content type of interactions are quite important in the theoretical and practical part of teaching in this area. In today's conditions interactivity is rather present, given the development of multimedia content, animations and simulations, which require constant student activity, together with different forms of online communication on the teaching material;

The forms in which certain segments of the content in this area are prepared are: theory in lessons, examples of solved programmes, programming tasks and questions:

• Theory in lessons can be prepared in the form of: text with programme elements definitions; illustrations with algorithms of basic programming structures. Electronic materials can have an addition: interactive lesson content, animations which complement or substitute the text, the purpose of which is to explain abstract concepts to students, through their visualization;

• Examples of solved programmes usually contain: text with the source code and additional explanation of the source code programme and illustrations with memory overview and programme execution output. Electronic editions of solved programme collections can also contain: interactive textual content for programme examples; animations for explaining the itinerary of programme execution and;

• Programme tasks should be systematized into those for research, team and individual homework, seminar paper or project, and prepare as a text of concrete tasks which should be solved in the required programming language, possibly with illustrations. In the electronic form the text of the task can be a content within the interactive applications, uploaded via the forum or other web tools;

• Questions in this area, with: connecting programme elements and their descriptions, alternative choice, multiple choice, filling in the programme elements or open-type. Just like tasks, the questions in the electronic form can be prepared within interactive applications of all kinds.

3.2 Development of Modern Blended Programming Courses

Modern blended learning environment [Bonk, Graham, 2006] is a environment the purpose of which adjustment to new the generation of students, which is achieved through combining of different: media and technologies in learning and teaching [Picciano, Dziuban, 2007]; teaching approaches, strategies and teaching methods; classroom and learning via internet.

In the first blended learning environments, classroom learning and teaching were dominant. The constant development of interactive multimedia, web systems and technologies, created a possibility for the development of new learning environments, and that was a significant step in the development of these environments. In modern blended learning environments, the following principles are insisted upon: adaptable classroom, flexible learning time, individual learning dynamics, regular communication throughout teaching and learning. Unlike the traditional learning environments, in which it was possible to implement only the original forms of the mentioned strategies of teaching of programming, modern blended environments introduce the internet, and partly become virtual, as shown in Table 2.

Table 2. Current strategies in the learning of programming and the environmental change for their realization

Teaching strategy	Forms of learning	Traditional environment	Modern environment
Direct Instruction	Listening, reading and analysing	Classroom, computer lab	Web platform for learning
Collaborative Learning	Team work; Exchange of ideas	Computer lab	Web tools for teamwork
Situated Learning	Practical work	Computer lab	Virtual lab
Self-directed Learning	Researching, revealing solutions	Computer lab	Web resources; Virtual lab

Blended courses implies using knowledge and experience of traditional environments, but it is necessary to work extra on broadening this knowledge and experience in modern conditions:

• Basic blended model of teaching (enhanced f2f learning) - realised within traditional studies, with 100% classroom lessons and extra forms of teaching via the internet;

• Advanced blended model of teaching (f2f & online, more online learning) - realised within distance studies: by substituting about 90% of all the lessons by online lessons, and realising via the internet all additional forms of teaching. Here too, the internet platform is using for online lessons and additional forms of teaching, but with much more complete teaching material: recordings of classroom lessons / audio-video presentations / multimedia textbooks with interactive simulations / applications for knowledge check.

Perennial research in the area of modern teaching methodology for programming by the authors of this paper, resulted in the development and realization of blended courses in this area, according to basic blended model of teaching in classical studies and according to advanced blended model of teaching in distance studies since, 2012/13 academic year. The teaching plans for these courses, Programming fundamentals, Programming languages and Object oriented design, are shown in Table 3.

Table 3. Teaching plan for described programming courses

"Programming fundamentals" topics
Structural programming, Algorithms of the program structures, language C
Data types, Operators and standard functions, Commands for flow control, language C
Arrays, Sorting of arrays, Use of pointers in arrays, Functions, language C
"Programming languages" topics
Dynamic memory assignment, Data structures, Dynamic linked lists, languages C/C++
Data input from command line, Working with text- and binary files, languages C/C++
Modular programming, language C, I/O streams, Classes and objects, language C++
"Object oriented design" topics
Classes features, Encapsulation, Inheritance, Polymorphism, language Java
Data and expressions, Working with data bases, Exceptions, language Java
Class diagrams, Activity Diagrams, Basic concepts of program design, language Java

4. EXPERIENCES IN APPLYING MODERN TEACHING STRATEGY METHODS IN PROGRAMMING COURSES

Every teaching strategy defines its own methods for interaction in the process of teaching and learning: teacher-content, student-content, teacher-student and student-student. Different strategies use different methods with various levels of teaching control and student activity in the teaching process, for the fulfilment of all these types of interaction. The same goes for the area of programming.

4.1 Modern Teaching Strategy Methods Implemented in Programming Courses

Short descriptions of modern teaching strategy methods which are implemented in blended courses of programming in the School of Electrical and Computer Engineering of Applied Studies in Belgrade, are shown in Table 4.

Table 4. Modern strategy methods implemented in the programming courses

Teaching strategy	**The most common activities in the classroom / via the internet**
Direct Instruction	**Teachers' activities:** Lecturing, presenting and reviewing programme elements and algorithms; Instructions on learning programme syntax; Demonstration on completed solved programmes; **Students' activities**: Interactive lectures following; Asking questions regarding elements and algorithms and completed solved programmes;
Collaborative Learning	**Teachers' activities:** Creating working teams or suggestions on the same; Instructions for team problem solving; Leading the discussion on the material; **Students' activities:** Team projects and problem solving; Active in the discussion on the material and problems; Indication of discussion on the lectures and problems;
Situated Learning	**Teachers' activities:** Instructions for using developed tools and surroundings; Instructions on programme solving and exercises; Instructions on writing programme seminars; **Students' activities:** Mastering using developed tools and surroundings; Programme solving; Writing programme seminars; Solving potential practical problems; Working on simulations of previously solved programmes; Researching previously solved programmes;
Self-directed Learning	**Teachers' activities:** Directions and recommendations for research on certain subject; **Students' activities:** Researching all of the subjects; Partial or complete reviews; Professional practice;

In modern environments for learning of programming, relation between present types of teacher and student activity is significantly changed compared to traditional systems [Watkins, 2005]. There were many more forms of teachers' activities in the lecturing strategy which dominated in the traditional learning environment whereas now it is insisted upon the change of this relation because certain forms of students' are present in the same level or more in some learning strategies which can be seen in Figure 1.
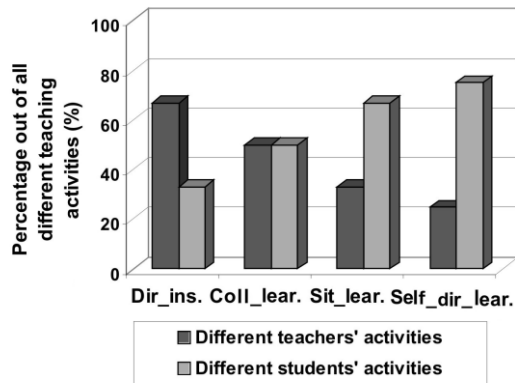

Figure 1. The relation between present forms of teachers' and students' activities in some modern teaching strategies for programming: direct instruction, collaborative, situated and self-directed learning

Experiences in applying above mentioned teaching strategies and methods in implemented blended learning environment in programming courses are briefly described further in this paper.

Experiences in applying modern teaching strategy methods - new forms for presenting teaching material with interactive smart board and internet access are very important for lessons in programming. Teaching materials can be available on the web, audio/video recordings of lessons in classrooms can be followed online or downloaded and used locally, watching audio/video material can be delayed and possible an arbitrary number of times, lessons and consulting can be implemented through audio/video conferences and other communication tools - this requires more teachers' than students' teaching activities.

Experiences in applying the collaborative learning method - cooperation is very important in modern learning environments. Discussions have become a necessary method in the collaborative learning strategy but also, the commonly used method in other modern strategies in learning of programming. It is no longer a question whether discussions should be included in programming courses because the experiences in their implementation show that they can offer great help to all participants - this requires the around same amount of teachers' and students' teaching activities.

Experiences in applying the situated learning strategy - this strategy demands that students practice solving problems that appear in real situations by simulating real conditions in programming. Students that learn in a blended environment get the chance to learn in a more situated manner because their participation in teaching and learning outside of the traditional classroom requires exactly that. Practical work commonly provides better understanding of abstract terms and success in studying after reading and listening to theory of programming - this requires more students' than teachers' teaching activities.

Experiences in applying the self-directed learning method - in this strategy, students are given recommendations and are free to research and get familiar with the theory that way and solve practical problems in programming. This strategy is used in different ways: checking material, essays and reports on covered teaching content on wiki pages and on blogs, practice in an online lab, working on tasks with the help of web tools. Practicing the use of this strategy in programming shows that it is very useful if students have mutually different pre-knowledge - this requires much more students' than teachers' teaching activities.

4.2 Recommendations: Modern Teaching – Enterprise of Teachers and Students

Experience from blended environments on the large number of programming courses ensues recommendations for the preparation of such teaching:

- use good experience with traditional teaching strategies and methods;
- set out all the conditions for realisation of the new teaching activities, long before the planned course;
- involve consultants in the specific area and pedagogy in the preparation of the new teaching activities;
- prepare online platform for learning, as well as all other planned web tools for the new teaching activities;
- make a detailed plan of teaching activities;
- try, if possible, to realise the planned teaching activities with other teachers;
- formulate the rules for the individual and team work for students;
- prepare the plan for communication with students about the teaching material;

Technology changes strategies and methods of teaching and consequently the roles of teachers and students. Experience suggests that the basic condition for modernizing teaching is that teachers accept innovations in order for students to do the same.

Teachers get new, highly demanding roles and assignments, but also an opportunity to have insight into learning methods of their students and to familiarize themselves better with them.

Students assume a very active role, while teachers are always available to answer all their questions, comments and objections related to the teaching material.

4.3 Development Trends and Future Research of Teaching Methods

There are high expectations for the results of future research in teaching strategies and methods, considering the constant development of new technologies and new roles of teachers and students. It is the same expectations in the area of programming:

- development of the learning environment for mobile devices constitute "mobile classroom" - teaching methods for programming are expected to be improved with:
  - uploading and views of audio / video content of lessons and exercises, instructions for tasks and practical work in programming – in mobile devices;
  - regular knowledge self - checks and discussions on teaching material and tasks - via mobile device;
  - teachers' and students' use of mobile devices in programming courses, both outside the classroom and in it, which represents trend of "bring your own device" in working context.
- development of the learning environment with distance online tools, in the form of virtual classroom constitute so called "classroom in the cloud":
  - preparing, development and views of lessons, exercises, knowledge self - checks and discussions on teaching material - on the cloud, without installing any kind of tools in local teachers' and students' computer devices;
  - working on solutions in programming, design, implementation and testing of code - on the cloud;
  - teachers' and students' activities more reliable and adaptive, free of charge or very affordable due to the reduced need for the local maintenance of programming environment and tools.
- development of the learning environment, web platforms, teaching materials and activities in the blended classroom, so called "flipped classroom":
  - outside the classroom: preparing, downloading, uploading and views of lessons, work instructions, programme examples and tasks;
  - outside the classroom: working on programme solutions, design, implementation and testing of code;
  - in the classroom: views of teaching material, questions and answers, discussions on teaching material and knowledge checks.

Blended learning environments for programming have already entered the practice of highly renowned education institutions all around the globe [Djenic, Krneta and Mitic, 2011]. In this area, like in all others, current teaching methods are constantly being modernized and the new ones are being developed, and the concept of teaching has shifted towards flexible cooperation between teachers and students.

5. CONCLUSION

Continuous work on the modernization of traditional, and the development of new teaching strategies and methods, as well as their application to modern blended learning environments, is currently an important strategic move in the development of higher education.

Learning of programming is closely related to the development of modern information and communication technologies, and it is therefore vital to continuously apply the latest achievements of modern teaching methodology in this area.

Perennial research in the area of modern teaching methodology for programming by the authors of this paper, indicated that the methods of all current teaching strategies are preferred in this study area. Modern teaching strategy methods incorporate interactive multimedia and interaction in teaching, which are important for this study area; Collaborative learning methods develop greatly needed creativity in solving programme tasks and stimulate the vital exchange of programming experience; Situated learning methods increase motivation and students' interest in solving programme problems, which are dominant in this study area; Self - directed learning methods capacitate student for lifelong development in this area, which is important for the further development of technologies.

In the application and further development of teaching methods in all the above mentioned strategies of this area, teachers have the task to explore / prepare / recommend students: web environment and tools for learning, as much interactive multimedia content as possible, animations and simulations, verified techniques for communication about teaching material and tasks, as well as mechanisms necessary for the evaluation of applied teaching methods.

The conducted research indicates that, with regard to combining various strategies and methods, blended learning environments require early and more thorough preparation than the traditional learning environments. Improvement of current strategies and methods, involves greater focus on the role of the teacher, as a tutor and mentor for students in the work on programming tasks and discussions on teaching material, as well as concentrating on the active role of students in employing these teaching methods.

Long-term experience in development of blended learning courses for programming indicates that in this area, establishing and encouraging cooperation between teachers and students in the process of learning, their joint work on solving practical problems that students have in mastering the teaching content and getting practice, as well as joint research in the learning area, can all lead to successful application and improvement of teaching strategies and methods in this area.

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