Flipped Computer Science Classes

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Abstract—Computer Science (CS) classes have been supported for ten years by multimedia materials in the form of podcasts. Even such materials did not improve quality of learning outcomes. In order to change this the idea of flipped classroom (FC) was used but situation did not change radically, so survey concerning students opinion on FC was conducted. Comparison of results of survey show big differences in attitude to FC and learning between students in Poland and students in United States or Canada. Conclusion of this research is sad—it is very difficult to motivate Polish digital natives to learn.

I. INTRODUCTION

DEA of inverting education is already nearly fifteen years old. One of the first papers in that field was published in 2000 [1]. This paper describes two parts of subject taught at Miami University while using the inverted classroom concept and analyzes the outcomes. Numerous technologies offered completely new possibilities for students to learn away from the classroom, while school period was used to perform collaborative experiments and worksheets. Authors of the paper concluded that the idea of inverted classroom offers alternatives for various learning styles and report that students favor that strategy. A different outline and evaluation of flipped education within a huge, primarily based on lectures, computer science course was published in 2002 in [2]. In this project new multimedia and video streaming application eTech was employed to change a course. In-class lectures were substituted by recorded lectures and auxiliary materials which could be viewed by students in the Internet independently. This make it possible to utilize the live period in the class for team problem solving facilitated by tutors. Another interesting paper in that field was published one year later in 2003 [3]. Within a series of five experiments hundreds of students from two different universities supervised by three different professors and six different teaching assistants took one semester long course in the field of casual and statistical reasoning in both traditional or online format. Within the frame of this project pre and post test results were compared. Features of the online experience which were helpful and which were not helpful were identified as well as most and least effective student learning strategies. Three years later a paper evaluating a web lecture intervention in a human–computer interaction course was published [4]. By utilizing lectures available in the Web before class more in-class period was used engaging students with hands-on tasks. Class time was spent on learning by doing rather than learning by listening. In 2007 Gannod presented his work in progress on how to use podcasts in an inverted classroom [5]. One year later Helmick presented integrated online coursework for computer science courses [6]. Last but not least in 2008 a paper describing how to use the inverted classroom to teach software engineering was published [7].

The present paper summarizes results of investigation presented in [8] and [9]. Starting from academic year 2012-2013 in some of groups podcasts (mainly software animations in the form of screencasts) were used in different way. Students were asked to watch podcasts at home. During classes students were supposed to be prepared to use software without any difficulties and to solve using it typical problems. First results of this experiment were to some extent promising. Students gained better scores in this case, but they were not very keen to spend additional time at home watching podcasts. They do prefer to be taught during classes. This problem was easily solved by adding simple point to subject regulations – students should be prepared to computer laboratories and this fact is checked by means of test before the class. In academic year 2013-2014 idea of flipped classroom was used for all groups – nine studying in Polish and two studying in English but only for part of material covering Computer Algebra System MathCAD Prime 3.0. Result of survey concerning students’ satisfaction will be presented in the paper.

II. FLIPPED CLASSROOM

It is much more effective to watch, passive by nature, screencasts at home and solve problems with tutor in class than the other way round. This observation leads to idea to revert the situation. Why not to ask students to perform
The place and role of Information Systems (IS), which can be treated in narrow sense as a term referring mainly to ICT, and Computer Sciences (CS) in curricula of Civil Engineering (CE) studies was described in previous paper [9]. Hardware and software information revolution has changed radically modern engineering workplace. The exact description of how transformation and circulation of information in the construction industry can and should look like can be found in [15]. In this work there are distinguished three groups of information: about the function, about the structure and about structure’s behavior (Fig. 2). In all stages of transformation, it is important to use computer tools. The process of analyzing the structure is invariably dominated by computer programs using the finite element method. In the process of synthesis, where there is room for optimization, there are also available computational tools, such as for example a spreadsheet Solver.

Fig. 2 Information flow in Civil Engineering

The last and the biggest block of classes is devoted to Computer Algebra System (CAS) namely to MathCAD Prime 3.0 which is described in books like [15] and [16]. Previous version of this program is better described in literature [17], [18] and [19]. Its presence in curricula of studies is a source of never ending discussions. In the opinion of many teachers students overuse MathCAD while preparing their design homework. It is enough that one
person creates a file and all remaining can simply enter only
the input data.

First part of MathCAD classes is devoted to solving
classical mathematical problems like symbolic calculations,
defining variables and functions, calculus (integrals,
derivatives, limits), matrix and vector operators and
functions and solving problems like linear and nonlinear
equations, minimization and maximization. Second part is
devoted to programming. In the beginning basic instructions
(if, for, while) and control statements (return, continue,
break) are introduced. The idea of this subject was inspired
by the book [20]. Detailed list of screencasts for that part of
the subject is in Table 1.

All course materials are stored on learning platform
Moodle. Taking into account different learning styles [21],
[22] learning materials are available in different forms
ranging from PDF files to screencasts (Fig. 3). The vast
majority of materials are in the form of screencasts which
are recordings of traditional classes (Fig. 4).

IV. SURVEY

The research concerning students’ satisfaction with
flipped classroom was conducted in academic year
2013/2014 on a group of 222 students studying in Polish
(PL) and a group of 51 students studying in English (EN).
Out of 222 PL students the questionnaire was filled by 211
students. Similar data are for students studying in English.
Questionnaire was filled by 49 out of 51 students. One third
of students studying in English were foreigners.

Winter Academy (School) of Programming

All animations (recordings) are divided into several groups:
Obligatory (compulsory) part
+ (p1) basic programming structures
+ (p2) matrices, vectors and indexing
+ (p3) series of numbers
Auxiliary (additional) part
+ (p4) functions expanded to series
+ (p5) numerical algorithms
+ (p6) sorting algorithms
+ (p7) recurrence

Please, watch at least some of them (obligatory, compulsory) carefully. During class we will
try to explain all your problems and answer on all your questions.
As you can see this part of material is absolutely different. You do not learn new features of
program (in this case MathCAD). You are supposed to learn how to use program in order to
solve different problems which are programming problems.

Because till Friday, 3rd January 2014 nobody visited this part of the course problems p3-p7
will not be animated. They are available only in PDF form.

Fig. 3. Sample Learning Materials on Moodle platform

TABLE I.
DETAILED TIMETABLE OF MATHCAD PRIME 3.0 CLASSES

<table>
<thead>
<tr>
<th>Week 1 – two hours</th>
<th>Week 2 – two hours</th>
<th>Week 3 – two hours</th>
<th>Week 4 – two hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MathCAD Window</td>
<td>XY plots</td>
<td>Linear equations - matrix and solve</td>
<td>Basic programming structures</td>
</tr>
<tr>
<td>MathCAD ribbon</td>
<td>Formatting XY plots</td>
<td>Linear equations - solve block</td>
<td>Sum of n first integers</td>
</tr>
<tr>
<td>Customizing worksheet</td>
<td>Range variables and XY plots</td>
<td>Nonlinear system of equations - solve block</td>
<td>Sum of first integers not bigger than n</td>
</tr>
<tr>
<td>Text and graphic regions</td>
<td>Parametric plots</td>
<td>Nonlinear system of equations - polyroots</td>
<td>Sum of even numbers from range m-n</td>
</tr>
<tr>
<td>Math region</td>
<td>Contour plots</td>
<td>Finding roots</td>
<td>For loop with step</td>
</tr>
<tr>
<td>Grouping and formatting</td>
<td>Formatting contour plots</td>
<td>Parameterizing solve block</td>
<td>Loop with changed m and n if m&gt;n</td>
</tr>
<tr>
<td>Symbolic calculations</td>
<td>Arrays and tables</td>
<td>Optimizing functions</td>
<td>Loop with step k+2 or -2</td>
</tr>
<tr>
<td>Simplifying expressions</td>
<td>Creating arrays</td>
<td>Optimizing with constraints</td>
<td>Testing different solutions (loops)</td>
</tr>
<tr>
<td>Expanding expressions</td>
<td>Contour plots for scattered data</td>
<td>Distance between two curves</td>
<td>Not nested if and wrong nesting</td>
</tr>
<tr>
<td>Factoring expressions</td>
<td>3D plots</td>
<td>Solving ODEs with solve block</td>
<td>Properly nested if</td>
</tr>
<tr>
<td>Collect keyword</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefs keyword</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitute keyword</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial fractions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Series</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identifiers</td>
<td>Generation of arrays with if</td>
<td>Creating a program</td>
<td>Matrices, vectors and indexing</td>
</tr>
<tr>
<td>Defining variables</td>
<td>Matrix operators</td>
<td>Defining functions</td>
<td>Minimum and maximum element in vector</td>
</tr>
<tr>
<td>Defining functions</td>
<td>Matrix functions (1)</td>
<td>Using operators</td>
<td>Minimum and maximum in one function</td>
</tr>
<tr>
<td>Units and label</td>
<td>Matrix functions (2)</td>
<td>Writing if statements</td>
<td>Minimum element and its index</td>
</tr>
<tr>
<td>Range variables</td>
<td>Linear equations</td>
<td>Writing if - else if statements</td>
<td>Sum of even numbers in vector</td>
</tr>
<tr>
<td>Derivatives</td>
<td>File access - output</td>
<td>Function for different ranges</td>
<td>Series of numbers</td>
</tr>
<tr>
<td>Integrals</td>
<td>File access - input</td>
<td>Loop with for</td>
<td>&quot;Theory&quot; of series of numbers</td>
</tr>
<tr>
<td>Limits</td>
<td>Curve fitting (1)</td>
<td>Loop with while</td>
<td>Series with for and while loops</td>
</tr>
<tr>
<td>Sums and products</td>
<td>Curve fitting (2)</td>
<td>Structure try on error</td>
<td>Slow convergence series</td>
</tr>
<tr>
<td>Complex variables and functions</td>
<td>Keyword explicit</td>
<td>Recursion</td>
<td>Alternative stop condition</td>
</tr>
<tr>
<td></td>
<td>Function root</td>
<td></td>
<td>Alternatives and art of programming</td>
</tr>
</tbody>
</table>

Fig. 4. Traditions classes being recorded as screencasts in MathCAD prime.
carried out in the traditional manner. In the computer laboratory equipped with 30 workstations there were two teachers. One of them demonstrated with multimedia projector solutions of the sample problems. The second teacher assisted students.

In order to perform survey Google Docs were used (Fig. 5, Fig. 6).

211 responses

Summary

1. FC angażuje mnie bardziej, niż tradycyjnie prowadzone zajęcia.

Questionnaire used in this survey consists of fifteen closed form questions and 6 opened form questions. Due to the nature of answers all questions were divided into three groups. In order to compare results of survey with other outcomes some of the questions were based on similar surveys: first one conducted in Canada [27] and second one described in blog Flipping with Kirch conducted by Mary Kirch from United States.

49 responses

Summary

1. The FC is more engaging than traditional classroom instruction
Observations from traditional classes were rather pessimistic. More than half of the students did not follow the presentation and did not perform similar tasks to those presented by the teacher. As presented in previous article [9] this material was rather unknown for students but they were simply not interested in learning new things. It is rather difficult to motivate digital natives to learn [23]. This is still a very important and significant problem even there were many books written on that subject [24]. The answer to this question is difficult when we consider digital natives who don’t care and who also think that they know everything [25] in the field of subjects like Applied Computer Sciences and Computing in Civil Engineering. Mendler presents one of the existing solutions – five key processes that motivate: emphasizing effort, creating hope, respecting power, building relationships and expressing enthusiasm. But digital natives being real partners for learning [26] are difficult and demanding partners.

V. RESULTS OF SURVEY

Scale of answers for all first five questions is from “strongly agree” to “strongly disagree”. Results for Polish language and English language students were compared with surveys from Canada. First of the asked questions was about level of engagement in traditional classroom instruction and flipped classroom (Fig. 7).

40% of students studying in Polish language strongly disagree or disagree with the statement what is in accordance with the observation, that nearly half of the students was not interested in traditional classes. Answers of students studying in English language are closer to the answers from survey conducted in Canada.

The FC is more engaging than traditional classroom instruction

Second question from that group was about potential recommendation of flipped classroom to a friend (Fig. 8).

I would not reccomend FC to a friend

For this question answers of students studying in Polish and English languages are similar but they definitely differ from the results of survey conducted in Canada. Nearly six times more students studying in Polish language in comparison to Canadian agree or strongly agree with the statement that they would not recommend flipped classroom to a friend.

Next question (statement) was very simple – I like watching lessons on video (Fig. 9). In this case answers for all three groups were very similar.

Fourth question in this group of questions was about bigger motivation to learn in the flipped classroom mode (Fig. 10).

In the case of this question answers of students studying in Polish language differ from the answers of two other groups. Nearly 40% of them strongly disagree or disagree with that statement that they are more motivated to learn in flipped classroom mode.

I like watching the lessons on video
The last question in this group is about improvement of learning in flipped classroom mode (Fig. 11).

Also in the case of this question answers obtained for students studying in Polish language are definitely different from results for two other groups. Nearly 40% of them strongly disagree or disagree with that statement. Answers for students studying in English and answers from survey in Canada are nearly the same. Nearly 80% agree or strongly agree with statement that flipped classroom has improved learning.

Second group of five questions is based on research conducted by Mary Kirch. Also in this case answers are on scale but they differ from question to question.

First question in this group is about rating flipped classroom. Scale of answers is from “very bad” to “very good” (Fig. 12).

Also in the case of this question answers for all groups are different. American students are most enthusiastic – more than 90% rated flipped classroom approach as very good or good. Students studying in Polish are definitely less enthusiastic and more skeptical – nearly 25% of them rated flipped classroom approach as very bad or bad.

Next question in this group compared feelings how flipped classroom helps to learn the material in comparison to traditional approach (Fig. 13).

Answers to this question are to some extend surprising. Number of answers much better or better is among students studying in English the highest – nearly 85% of such answers. Traditionally students studying in Polish gave the highest number of negative answers – 35% of them answered that flipped classroom helped them to learn in comparison to traditional approach much worse or worse.

Fourth question was about feelings towards flipped classroom approach. Scale of the answers was from “I hate it” to “I love it” (Figure 14). Results in this point differ also...
because American scale was four point scale without neutral answer. Students were supposed to express only negative or positive feelings.

![Fig. 14. Answers on question 2.3](image)

As in the case of previous questions for students studying in Polish language the number of definitely positive answers I love it is the lowest – only 3%.

In next point question how much did you learn in flipped classroom in comparison to traditional was asked (Fig. 15).

![Fig. 15. Answers on question 2.4](image)

More than 25% of Students studying in Polish language answered that they learned much less or less while more than 30% of students studying in English language or American students answered that they learned much more.

The last question was: how much were you challenged in the FC comparing to traditional (Fig. 16).

![Fig. 16. Answers on question 2.5](image)

I. FINAL REMARKS

One of the pressures on universities is the rapid development of new information and communication technologies for the provision of education and training. Wide opportunities in open and distance learning create new markets. Moreover the principle of lifelong learning extends the age groups to which university can offer education. Additionally the principles of new techniques can be applied to traditional markets – regular intramural students. All Polish universities willing to use modern information and communication technologies face common opportunities, threats and constraints. A constant struggle between pressure to change and fear and resistance to change is visible in Poland. Teachers’ attitudes are a major obstacle to the introduction of change. There is an internal brake on the efforts to make changes through using new technologies: resistance from people. Reference can be made to a “frozen middle” resisting attempts to change from both the top of the institutions (authorities) and from the bottom (students). Students’ demands are a powerful factor forcing universities to exploit the potential of new technologies to improve learning experience. But the question “how to change the unchanging” is still open [28]. Moreover one should add to this question a new one – “how to motivate digital natives to learn?” [23].

Flipping the classroom is not the only way in which “how to change” and “how to motivate” problems can be solved. One of them is classification of learners using linear regression [29], because proper classification of learners is one of the key aspects in e-Learning environments. Second possibility is to enhance online educational environment what can be obtained by providing platform side intelligent functionalities in the shape of a recommender system or learning path builder [30]. Another possibility is to use system that allow the organization of a set of teaching and learning activities and meets, at its highest level of detail all the elements that compose the curriculum: setting goals and content, design and development of activities and
evaluation, organization of space and time, and providing the necessary resources [31]. Next chance is to implement a Learner-centered learning which is constructivism based and Competence directed in which we define general competencies, domain competencies and specific course competencies [32]. Last but not least are also another innovative teaching methods for blended learning like for example Drawer [33] or recognizing different learning styles while designing e-courses [34].

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