FLIPPED LEARNING IN A PROGRAMMING COURSE: STUDENTS' ATTITUDES

Ásrún Matthíasdóttir,

[1]Department of Science and Engineering, Reykjavik University, Iceland

Hrafn Loftsson

Department of Computer Science, Reykjavik University, Iceland

ABSTRACT

Student-centred learning (SCL), which puts the student at the centre of the educational process, has been gaining focus in recent years. This is due to doubts that teacher-centred learning (TCL), which puts the teacher in the primary role in the learning process while students take a more receptive role, is the best way for students to learn. SCL is related to active learning, team-based learning (TBL), flexible learning, experiential learning, digital learning, flipped learning (FL), and blended learning. In this paper, it stands for a learning environment where students have more choices and control over their learning and are active participants in the educational process. We introduce an implementation of a novice-programming course that was completely reorganized according to SCL, TBL and FL, using online videos, online exams, and group work, with a minimal formal presentation from the teachers. In the course, Canvas was used as the Learning Management System, Piazza as a question and answering system, and Mimir Classroom as a system for assignments, projects, quizzes and exams. As the course setup was new for the students, a survey was conducted to assess how they perceived the educational process. We discuss the results in relation to the CDIO standards 1 and 8, program philosophy and active learning. In short, the students felt that the course was overall good learning experience and liked the online resources, especially the videos.

KEYWORDS

Student-centred learning (SCL), flipped learning (FL), team-based learning (TBL), novice-programming course, online learning, CDIO Standards: 1, 8.

INTRODUCTION

Teaching methods and organization of a course are essential for the learning process and have an impact on students' engagement and the outcome of their educational work. Teachers are the central performers in educational change (Fullan, 2001; Sarason, 1990; Shulman, 2004; Fullan, 2007; Hargreaves & Shirley, 2009) along with school authorities. Educational changes take time and as Fullan (2007) says: "success it not just about being right; it is about engaging

diverse individuals and groups who are likely to have many different versions about what is right and wrong" (p. 40). Teachers can choose between numerous diverse methods of how to provide study materiel and how to organise their courses. In recent years, with more and better opportunities of online educational options, many teachers have looked into how they can implement those new options and how they should layout their courses in a different and even new way. The purpose of this study was to look into students' attitudes towards a new organization of a novice-programming course, built on the student-centred learning (SCL) approach, using flipped learning (FL) and team-based learning (TBL). Overall, there has been a growing understanding of the significance of students' attitudes towards their educational environment, the content and layout of courses, and use of information and communication technology (ICT) (Marshall & Cox, 2008; Matthíasdóttir, 2015).

How to teach novice students programming has been debated over the years, both the layout of teaching, teaching methods and what programming languages to teach (Marion, 1999; Matthíasdóttir & Geirsson, 2011; Kunkle & Allen, 2016; Hendrix & Weeks, 2018). C, C++ and Java have been the most used languages in both industry and academia, but Python has gained more popularity over the recent years (Ben Arfa Rabai, Cohen & Mili, 2015). ACM/IEEE teams on computing curricula do not recommend any particular programming language and the industry is still using programming languages with background in the late sixties/early seventies (C), and variations thereof (C++, Java). Therefore, it is up to academia to take the lead and use languages that best assist students to master programming (Ben Arfa Rabai, Cohen & Mili, 2015). In the first-semester programming course discussed in this paper, it was decided to change from C++ to Python, as it was believed to be a much more convenient development environment for novice programming students.

Teaching methods are important and the SCL approach has gained more interest due to doubts that teacher-centred learning is the best way to teach. The driving force has also been the changing nature of the student population (Lea, Stephenson & Troy, 2003), where technology is now, in fact, an integrated part of students' lives. All the new online options available with the use of ICT and technology-enhanced learning (TEL) give teachers new opportunities to adapt SCL in their courses.

Cannon and Newble (2000) provide a useful definition of SCL as "ways of thinking and learning that emphasize students' responsibility and activity in learning rather than what the teachers are doing. Essentially SCL has student responsibility and activity at its heart, in contrast to a strong emphasis on teacher control and coverage of academic content in much conventional, didactic teaching." (p.16). Here SCL is viewed as a learning environment, where students have more choices and authority over their learning and are actively participating in the learning process. SCL can be used with the support of different teaching methods like flexible learning, experiential learning, digital learning, and blended learning.

Educators have recognized FL as an effective and inventive educational approach where traditional instruction is changed by switching in-class instruction time with out-of-class practicing time. The students' out-of-class learning plays a central role for students and teachers in-class work, and it is important that students prepare out-of-class so they can take active part in in-class work (Mason, Shuman & Cook, 2013). FL is not only about providing students with videos to watch before class, it is also about teachers guiding and assisting them to think, reason and discuss, and to enhance learning with communication, good feedback and problem solving (Hwang & Wang, 2015).

TBL is a convenient instructional approach especially for the purpose of practicing teamwork skills. In TBL, the student is at the centre, where the teacher directs the instructional method as the students are divided into small teams of five to seven aiming at solving problems. Traditional lectures are not provided as the students are assumed to be acquainted with the content out-of-class. When attending class, the students take an individual multiple-choice test and then discuss in groups the same test and get feedback on the group answers. The teacher then clarifies what the students have struggled with and they then continue working in groups on relevant problems and discuss their solution with other groups in the class under the teachers' facilitation (Dolmans, Michaelsen, van Merriënboer, & van der Vleuten, 2015).

Technology-enhanced learning (TEL) is here aligned with Laurillard, Oliver, Wasson, Hoppe (2009), where technology is used to encourage new types of learning experiences, but at the same time to increase current learning settings. Online material, especially videos, are the learning material format that has recently gained most interest and distribution by students. The availability of online educational videos is a fast-growing fact that students can make use of with or without teachers' guidance. This gives the teacher many opportunities to use ready-made videos by other professionals and, in a way, it can be stated that videos are not only a substitute for the teacher's lecturers but also the new book for the students.

Evaluation of students' work is essential to guide students through their study and to add to their educational process (Ardid, Gómez-Tejedor, Meseguer-Duenas, Jaime Riera, & Vidaurre, 2015). Use of different assessment methods gives a better overview of students learning. Online exams and quizzes, with immediate scoring, can be useful and versatile. They are good options for students to receive instant feedback and for the teachers to use continuous assessment without overloading their work. Readiness Assurance Tests (RATs) are a good way of using online multiple-choice tests and they have proved to be a good way of preparing students for tests (Bartlett Ellis, Carter-Harris, & MacLaughlin, 2016). RATs are an integrated part of a TBL layout in classes, where students first take a test individually (I-RAT) and then with a team (T-RAT) (Gullo, Ha & Cook, 2015).

Novice-programming course

In this paper, we describe the results of a survey conducted among students in a 12-week novice-programming course in the Department of Computer Science at Reykjavik University. The course was completely reorganized using the SCL methodology, TBL and FL, and using online materials, like videos and tests, but with no formal conventional lectures from the teachers.

The 325 students in the course were divided into seven sections and then into groups of 5-6. Each section had a class twice a week for 4*45 minutes each day, where they were assisted and guided by one teacher and one teaching assistant. The students were expected to come prepared to the class by reading a chapter in the course textbook and watching short YouTube videos selected by the teachers. The videos were mainly demonstrations of the textbook material.

In line with TBL and RATs, most class hours started with a short individual online test, but before the test, the students could ask questions related to the content of the day. After the individual test, the students worked in groups to solve the same test again (both the individual test and the group test counted towards the course grade). Then the groups worked on short programming problems, for which each student had to hand in his/her own solution at the end of the class, or no later than four hours later.

Weekly larger programming projects were also assigned for the students to work on out of class, and additionally, two midterm exams. At the end of the course, there was a three-hour final exam taken in the same environment as students had been working in during the course. The programming language was Python, the university learning management system (LMS) was Canvas (www.canvalms.com), Piazza (www.piazza.com) was used for questions and answers as it has been used in the department for several years, and Mimir Classroom (www.mimirht.com) for administrating projects and exams. The leading instructor of the course was responsible for the organization and six instructors were tutoring the sections with one teaching assistant each.

The main research question in this study was: What do the students believe that matters most regarding their experience in the SCL and TBL approach of the novice-programming course?

METHOD

Participants
An online survey was e-mailed to 325 students in the introductory programming course. In total, 178 (55%) students answered, 114 (64%) males and 65 (36%) females. The participants' average age was 24.4 years, ranging between 18 and 46 years. Most students, or 148 (83%), were first-semester students, 119 (67%) rated their programming skills very little or little before they entered the course, and only 14% (24) rated it as great or very great.

Measures

The online survey consisted of twenty-three questions, designed especially for the purpose of the study. Three are background questions about gender, age and semester, and one question is about the participant's programming skills before he or she started the course: "How much computer skills do you consider you had before you started the course?", rated on a five-point Likert scale, ranging between "Very little" and "Very great". The term programming skills was not defined in the questionnaire and the participant could only select one single answer.

Fifteen questions ask about the course and the student's learning experience. They were all rated on a five-point Likert scale, ranging between "Totally disagree" and "Totally agree". The questions are as follows.

- Six questions are about the organisation of the course, class hours, the YouTube videos and the exams: "*The organization of the course is good", "The class hours each week are useful to me", "The book of the course helped me in my study", "The videos in the course helped me in my study", "I like the organization of the short exams at the beginning of class"* and *"I like the arrangements of the midterm exams".*
- Four questions are about communication with the teachers and fellow students: "*Communications with teachers in class help me to study", "To discuss with fellow students helped me to study", "To discuss with fellow students outside the class hours helped me study"* and *"I like to work in a group with fellow students".*
- Five questions are about the students' use of online resources and the textbook: "*I usually read the book before class", "I usually watch the video in the course before the class", "I liked to use Canvas in my study", "I liked to use Piazza in my study"* and *"I like to use Mimir in my study".*

One question asked about the students' attitudes towards the course: "*This course is overall a good learning experience*". This question was used as the outcome variable in the main analysis (linear regression) and rated on a five-point Likert scale, ranging between "Totally disagree" and "Totally agree".
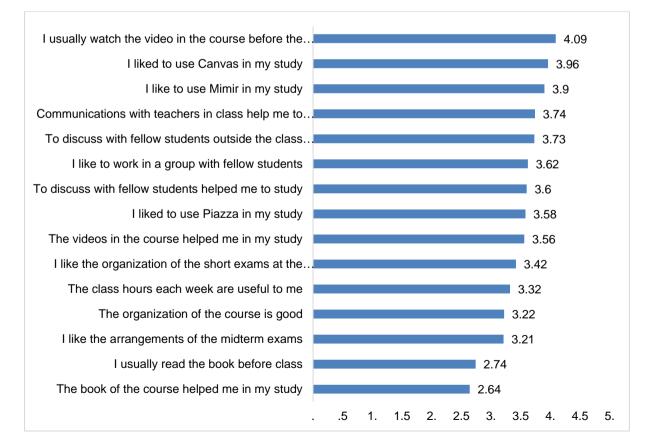
Three additional questions were asked: "*I feel the course is lacking traditional lectures", "I have done well in this course"* and *"Group work is time-consuming*". They were rated on a five-point Likert scale, ranging between "Totally disagree" and "Totally agree".

Procedure

The survey was put online in the system Free Online Surveys (https://freeonlinesurveys.com) and a link was sent to the students by e-mail in the 10th week of the course. Data analysis was carried out in Excel and the Statistical Package for the Social Sciences (SPSS).

RESULTS

Figure 1 shows the mean scores on the fifteen questions about the students' behaviours in the course and their attitudes towards its layout, communication and learning resources. The students seem to be most active in using the videos, Canvas (the learning management system) and Mimir Classroom, and value both communications with the teachers and their fellow students. The textbook did seem only moderately helpful and not frequently read before class.

Figure 1 The mean scores on the 15 questions (scale 1-5).

To investigate the relative contribution of fifteen predictor variables described in Table 1 to the variance of the outcome variable, „*This course is overall a good learning experience*" (mean score 3.53) linear regression was carried out (force entry method). The fifteen variables were entered into the regression in three blocks. The first block included six variables related to the organisation of the course, class hours, videos and exams, the second block included four variables related to communication with the teachers and students, and the third block included five variables related to the students' use of the online resources and the textbook. Eight of the fifteen predictor variables shown in the table explained 62% of the variance in the final model, the first block explaining the largest part or 54%, and the second and the third block adding another 2% and 9%, respectively. In the final block, the weekly class hours (β=0.39) was the strongest single predictor, followed by the organisation of the corse (β=0.24), the use of Piazza (β=0.23), the online videos (β=0.23) and using the videos (β=0.21).

Table 1 Linear regression, with the question "*This course is overall a good learning experience*" as an outcome variable.

	Block 1		Block 2		Block 3	
	β	t	β	t	β	T
The organization of the course is good	0.31	4.66***	0.29	4.36***	0.24	3.75***
The class hours each week are useful to me	0.35	5.31***	0.35	4.67***	0.39	5.64***
The book of the course helped me in my study	0.13	2.30*	0.12	2.20*	0.16	2.43*
The videos in the course helped me in my study	0.15	2.48*	0.15	2.44*	0.23	3.69***
I like the organization of the short exams at the beginning of class	-0.04	-0.65	-0.04	-0.71	-0.04	-0.76
I like the arrangements of the midterm exams	0.15	2.80**	0.14	2.58*	0.12	2.25*
Communications with teachers in class help me to study			-0.03	-0.42	-0.06	-1.01
To discuss with fellow students helped me to study			0.16	1.80	0.08	0.97
To discuss with fellow students outside the class hours helped me study			0.02	0.25	0.02	0.30
I like to work in a group with fellow students			-0.15	-2.06*	-0.16	-2.42*
I usually read the book before class					-0.10	-1.53
I usually watch the video in the course before the class					-0.21	-3.77***
I liked to use Canvas in my study					0.01	0.23
I liked to use Piazza in my study					0.23	4.30***
I like to use Mimir in my study					0.02	0.37
Adjusted R	0.54		0.54		0.62	
R2 Change	0.55		0.02		0.09	
ANOVA F-value (df)	33.50 (6.163)***		21.08 (10.159)***		19.58 (15.154)***	

*p<0.05, **p<0.01, ***p<0.001

Half (89; 50%) of the students claimed they had done well in the course (so far), nearly half (88; 49%) found the course lacked traditional lectures, and 52 (29%) claimed group work was time-consuming.

DISCUSSION

This study investigated student´s experiences in a SCL, TBL and FL designed novice-programming course at the university level. The aim was to gain a deeper understanding of the issues related to what options students use and like in their studies. It is a complex matter due to the many options teachers can use to support SCL, TBL and FL, and the different views people have of the implementation and usefulness of ICT in education.

The importance of understanding students' perception of their learning experience is one of the central essentials in the development of effective learning environments. For FL, TBL and RAT to be successful, the students need to come prepared to class. If they are not prepared, they cannot take active part and do not get the most out of the educational work that goes on. Thus, students' use of learning recourses and their attitudes towards the course affordance and organisation is important for their learning experience. It is clear from the results that the students do not value the textbook as a support to their study, but they like the videos and claim to use them. Our findings suggest that videos in programming education get students´ attention and encourage them to prepare for class. Research has shown that images are usually processed and remembered better than when reading or hearing material (Shorter & Dean, 1994) and videos are more pleasing compared to traditional lectures to students Bhadani, Stöhr, Hulthén, Quist, Bengtsson, Evertsson, & Malmqvist, J. (2017). The popularity of watching videos among young people's today offer teachers the opportunity to reach out to students and use instructive videos more frequently.

The fifteen predictor variables entered in the linear regression explained 62% of the variance of the students' learning experience in the course. The results indicate that the students relate their learning experience mostly to the weekly class hours, the use of Piazza and the organisation of the course as well as the videos.

It is of concern that the students did not find the textbook helpful and did not use it to prepare for class. This raises the question, how do we get students to understand that they need to be active, take part and prepare for class to be successful? They come to university after 13-14 years in the educational system so they have developed their study style that for some of them may not be a successful one when at the university level. One way to change this situation could be to emphasise the students' learning style at the beginning of a course so that they realise how they need to work in a SCL environment.

Technology will continue to be a motivating force for designing courses built on SCL, TBL and FL. Organising a course with this methodology can activate the students and encourage them to identify for themselves what and how they learn and increase their motivation for successful learning. This is in line with the CDIO standard 8, teaching and learning based on active experiential learning methods and could be an option for educators that are working with the CDIO vision for engineering education.

REFERENCES

Ardid, M., Gómez-Tejedor, J. A. Meseguer-Duenas, J. M., Jaime Riera, J. & Vidaurre, A. (2015). Online exams for blended assessment. Study of different application Methodologies. *Computers & Education*, 81, 296-303. Doi: 10.1016/j.compedu.2014.10.010

Bartlett Ellis, R., J., Carter-Harris, L., & MacLaughlin, P. (2016). Preparing students for success on examinations: Readiness assurance tests in a graduate-level statistics course. *Journal of Nursing Education*, 55(1), 41-44. doi:http://dx.doi.org/10.3928/01484834-20151214-10

Ben Arfa Rabai, L., Cohen, B., & Mili, A. (2015). Programming language use in US academia and industry. *Informatics in Education*, 14(2), 143–160. Dou:10.15388/infedu.2015.09

Bhadani, K., Stöhr, C., Hulthén, E., Quist, J. Bengtsson, M., Evertsson, M., & Malmqvist, J. (2017). Students perspectives on video-based learning in CDIO based project courses. *Proceedings of the 13th International CDIO Conference*. Canada.

Cannon, R., & Newble, D. (2000). *A guide to improving teaching methods: A handbook for teachers in university and colleges*. London: Kogan Page.

Dolmans, D., Michaelsen, L., van Merriënboer, J. & van der Vleuten, C. (2015). Should we choose between problem-based learning and team-based learning? No, combine the best of both worlds! *Medical Teacher,* 37(4), 354–359. Doi: 10.3109/0142159X.2014.948828

Fullan, M. (2001). The return of large-scale reform. *Journal of Educational Change*, *1*(1), 5–27.

Fullan, M. (2007). *The new meaning of educational change* (Vol. 4). New York, NY: Teachers College Press.

Gullo, C., HA, T., C. & Cook, S. (2015). Twelve tips for facilitating team-based learning. *Medical Teacher,* 37(9), 819–824. Doi:10.3109/0142159X.2014.1001729.

Hargreaves, A. P., & Shirley, D. L. (Eds.). (2009). *The fourth way: The inspiring future for educational change*. Thousand Oaks, CA: Corewin Press.

Hendrix, R. & Weeks, M. (2018). First Programming Language for High School Students. In E. Langran & J. Borup (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 1896-1903). Washington, D.C., United States: Association for the Advancement of Computing in Education (AACE). Retrieved January 10, 2019 from https://www.learntechlib.org/primary/p/182788/

Hwang, G-J., Lai, C-L. & Wang, S-Y. (2015). Seamless flipped learning: a mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education*, 2 (4), 449–473. Doi:10.1007/s40692-015-0043-0

Kunkle, W. M. & Allen, R. B. (2016). The Impact of Different Teaching Approaches and Languages on Student Learning of Introductory Programming Concepts. *ACM Transactions on Computing Education (TOCE)*, 16(1). Doi:10.1145/2785807

Laurillard D., Oliver M., Wasson B., Hoppe U. (2009) Implementing Technology-Enhanced Learning. In: Balacheff N., Ludvigsen S., de Jong T., Lazonder A., Barnes S. (eds) *Technology-Enhanced Learning*. Springer, Dordrecht

Lea, S. J., Stephenson, D. & Troy, J. (2003). Higher education students' attitudes to student-centred learning: beyond 'educational bulimia'? *Studies in Higher Education*, 28(3.), 321- 334. Doi:10.1080/03075070309293

Marion, W. (1999). CS1: what should we be teaching? *ITiCSE-WGR '99*. Working group reports from ITiCSE on Innovation and technology in computer science education, pp. 35-38. Doi:10.1145/349316.349388

Marshall, G., & Cox, M. J. (2008). Research methods: Their design, applicability and reliability. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education*, 20, 983–1002. Boston, MA: Springer.

Matthíasdóttir, Á, (2015). After they turn on the screen: Use of information and communication technology in an upper secondary school in Iceland. PhD thesis. University of Iceland. Retrieved 23. December 2018 from   https://skemman.is/handle/1946/23193

Matthíasdóttir, Á. and. Geirsson, H. J. (2011). *The Novice Problem in Computer Science.* Proceedings of the International Conference on Computer Systems and Technologies - CompSysTech'11.

Mason, G. S., Shuman, T. R., & Cook, K. E. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. *IEEE Transactions on Education*, 56(4), 430-435.

Sarason, S. B. (1990). *The predictable failure of educational reform: Can we change course before it's too late?* San Francisco, CA: Jossey-Bass.

Shorter, J., & Dean, R. (1994). Computing in collegiate schools of business: are mainframes & stand-alone microcomputers still good enough? *Journal of Systems Management*, 45(7), 36e41.

Shulman, L. S. (2004). *The wisdom of practice: Essays on teaching, learning, and learning to teach*. San Francisco, CA: Jossey-Bass.

BIOGRAPHICAL INFORMATION

Ásrún Matthíasdóttir is an Assistant Professor in the Department of Science and Engineering at Reykjavik University. Her research interests are in equality in education, the use of information and communication technology (ICT) in education in a wide context and the use of new teaching methods in science education to improve the quality of education.

Hrafn Loftsson is an Associate Professor in the Department of Computer Science at Reykjavík University. His research is in the field of Natural Language Processing (NLP), including morphological analysis, part-of-speech tagging, parsing, corpus construction, machine translation and computer-assisted language learning.

Corresponding author

Ásrún Matthíasdóttir
Reykjavik University
Menntavegur 1
101 Reykjavik
Iceland
asrun@ru.is