EXPLORING STUDENT ENGAGEMENT IN PROGRAMMING SESSIONS USING A SIMULATOR

Olufemi Isiaq and Md Golam Jamil
Southampton Solent University
United Kingdom

Abstract

The classification of programming as an art brings the importance of creativity as a requirement to become an effective programmer. However, the learning and teaching of programming subjects have been widely perceived to be difficult. Subsequently, students tend to be less engaged in programming classes, which in-turn results in significant dropout rates for programming related courses. This research investigates the use of a simulator for learning and teaching of programming topics with a specific focus on the embodiment of student engagement and disciplinary pedagogies.

Keywords: student engagement, programming, simulator, learning

Introduction

Programming is often classified as art rather than science based on its unique nature of contents and learning procedures. Teaching programming to university students reflects a high level of skill orientation where students are required to possess strong intuition on how things should work. Also, the learning of this subject requires a significant correlation between meaningful learning and student engagement. These requirements have also been mentioned by other researchers, such as Kujansuu and Tapio (2004), who have advocated that meaningful learning is ensured to effectively gain programming related knowledge and skills. Meaningful learning is in fact a catalyst for student engagement and quality education (Willingham, Pollack, & Lewis, 2002). However, the perspectives of student engagement, and, also, non-engagement issues, in the programming field has neither been extensively discussed nor publicised.

In this paper, we explore the extent of student engagement in learning and teaching of programming topics, particularly using a simulator. We chose a UK University's programming oriented module as our target context and investigated student perceptions and reflections on its educational procedures.

Student Engagement: Considerations and Challenges

The term *student engagement* gains varied meanings and contains multiple components in educational research (Lawson & Lawson, 2013). Whereas, in broader dimension, it covers student retention at educational institutions, a more focused discussion indicates student participation and performance in learning activities in specific classes (Darling-Hammond, 2010; Eccles & Wang, 2012). However, in all these cases, student engagement addresses one of the key educational goals which is the transmission of knowledge and skills through learners' time, uptake, resources and involvement (Krause, 2005).

The importance of student engagement in learning is indisputable (Trowler & Trowler, 2010). Students only learn when they are involved (Astin, 1985). In a formal educational setting the engagement of students may indicate the overall quality of learning and teaching (Kuh, 2009). Particularly, in a higher education context, this may directly refer to students' achievements and competences (Kahu, 2013). Additionally, student engagement contributes to their persistence and satisfaction in the process (Pascarella & Terenzini, 2005).

Student engagement is multi-layered, and there are different angles of vision to look into it (Fredricks, Blumenfeld, Friedel, & Paris, 2005). One of the approaches is to see it through students' internal conditions, such as behavioural, affective and cognitive phenomena (Appleton, Christenson, & Furlong, 2008). Conversely, the external or ecological factors, such as learning culture and the influence of peers, family and society can be considered to realise their engagement in learning (Lawson & Lawson, 2013).

Nature of Engagement in *Meaningful Learning*

The key objective of student engagement in a classroom environment is to gain knowledge by following teachers' delivery, answering questions and solving problems through the exploration of subject matters (Mayer, 2002). In many cases, this happens via *rote learning*, which is limited to remembering the instruction or information provided in classrooms. Conversely, *meaningful learning* involves cognitive processes, such as critical thinking, active discussion and problem solving (Mayer, 2002). In this process students get opportunities to plan, reflect and share knowledge.

In a classroom situation, student engagement is a dynamic process that happens through personal acts of attention or motivation of students and their interaction with teachers and peers, which are commonly termed as *social-cultural acts* (Lawson & Lawson, 2013). More precisely, there may be three major dimensions of the engagement for meaningful learning in a classroom, namely behavioural, emotional and cognitive ones. These dimensions and relevant factors, elaborately explained by Fredricks and McColskey (2012), are briefly mentioned below.

First, behavioural engagement refers to students' attention to class activities and attempt to participate in those. These can also be negative when students pretend to be attentive, or they come in a class without preparation, resulting in failing to achieve meaningful learning. Second, students' self-belief, personal motivation and peer support for learning indicate their emotional engagement in a classroom learning environment. The relationship of students with teachers and peers are two important indicators that can help measure this kind of emotional or affective engagement. Students' cognitive engagement, the third dimension, includes their planning or strategies for learning, self-regulation and recognition of the value of engagement.

Student Engagement in Programming Sessions

Learning to become an effective programmer requires a substantial level of imagination and creative skills. While creativity is not well represented in literature, the key characteristics that promote creative skills have been interpreted to include pedagogical approaches, physical environment, relationship between teachers and learners, availability of resources, use of time and the use of other environment outside educational institutes (Davies et al., 2013). Severally, a reasonable link between students' motivation and engagement and creativity has been highlighted in literature (Craft, Chappell, & Twining, 2008). Not only has this strengthened the assumption of high level engagement as a requirement for students to acquire programming skills, it subsequently reflects the impact of engagement as a necessary condition to become an effective programmer.

However, students may be confronted with different problematic situations in a creative and imaginative programming class. An impactful characteristic might be students' behaviours, which strongly influence their problem-solving skills, reflective practice and an exchange of feedback (Perkins, Hancock, Hobbs, Martin, & Simmons, 1986). Additionally, there may be challenges related to learning styles, learning speed and motivation (Jenkins, 2002). By acknowledging these problems, we decided to gain the following baseline information about student engagement in a programming class where a simulator was used:

- Types and nature of student engagement
- Roles of teacher and students in the process

Methodology

As the issues and dimensions of student engagement are vast and complicated, for the convenience of a context-specific and target group focused investigation it is important to set some research boundaries in this study. Therefore, it was essential to choose a particular teaching/learning unit and associated factors related to student engagement. Subsequently, 32 students of Level 5 on a programming module in a UK University were included as research participants. Besides, we decided to explore only the classroom environment related to student engagement in our study.

Approaches and Tools

The study followed a mixed-method research approach. Several benefits were assumed by following this methodology, such as a greater scope of convergent validation or triangulation of research data (Fielding, 2012), possibility of gaining richer perspectives and arguments in relation to relevant theories and practices (Johnson, Onwuegbuzie & Turner, 2007), and being able to draw comprehensible conclusions (Teddlie & Tashakkori, 2009). A technology-enhanced survey and a written open-ended questionnaire were used to collect qualitative and quantitative data respectively with the students in two classes. In the class a simulator was used for the learning and teaching of Programming. A simulator is a virtual machine that imitates real-world actions and processes. In this instance, the tool imitates the steps of a 'program event', indicating the procedures to be followed in completing such processes.

Survey. We administered an 18-item survey questionnaire using technology among 32 students of a programming unit. The statements were in three areas, namely behavioural, affective/ emotional, and cognitive. A PowerPoint document was prepared where each slide contained a statement. At the end of each Web Application session, students were given clickers for voting synchronously and anonymously. The statements appeared on screen consecutively providing with sufficient time for responding.

Table 1

Survey Questionnaire Items

Behavioural	1. I actively participated in the class.
	2. I was more attentive in this class compared to other classes that did not use a simulator.
	3. There was no opportunity to work with classmates.
	4. I was able to link my learning with own experiences.
	5. This class motivates me to share my ideas with others.
	6. I asked questions about the simulator tool for clarification.
Affective/ Emotional	7. Using a simulator made the class fun.
	8. The simulator tool has motivated me to participate in the given tasks.
	9. The class did not have any clear learning goal.
	10. I feel the class is useful for my future profession.
	11. There was clarification when I had doubts.
	12. I would recommend today's session to my friends.
Cognitive	13. The session provided me with challenging tasks.
	14. I knew what I was supposed to learn.
	15. I learned things that might be useful in the practical world.
	16. The learning I have gained is valuable.
	17. I was able to link my learning with other lessons.
	18. After attending the session, I feel I now understand the concept of client server programming better.

Responses included student perceptions and self-assessment in a five-point Likert scale (Likert, 1932), and were processed using a statistical software, SPSS. Item 3 and 9 are negative statements, so reverse coding was applied.

Critical Incident Questionnaire. We also used a widely accepted five-item open ended questionnaire as a post-class learning assessment tool (Brookfield, 1995). The tool, as Brookfield explained, can collect "vivid happenings" of a class, particularly the experiences of students on critical moments of learning progression (Brookfield, 1995, p. 114). In addition, this is helpful to realise the extent of student engagement and the associated reasons, through student reflections and feedback (Hedberg, 2009). A paper-based handout with the questions below were administered among the student participants for their responses (the questions are modified from Brookfield, 1995, p. 115).

- When did you feel most engaged with what was happening?
- When did you feel most distanced from what was happening?
- What action of your teacher/classmates did you find most affirming and helpful?
- What action of your teacher/students in the class did you find most puzzling or confusing?

- What element/activity of the class surprised you the most (for example, something that someone did in the class, your own reactions, or anything else that occurs to you)?

The Critical Incident Questionnaire allowed students to reflect on personal engagement events, moments and to identify the contributing factors, such as the role of teacher and peers. As the participating students responded just after their sessions, the data have been more specific and reliable. The responses were processed and analysed by NVIVO software.

Findings

The survey and Critical Incident Questionnaire provided qualitative and quantitative data. Whereas the survey data revealed the states of targeted students' behavioural, emotional and cognitive engagement in a programming class, the Critical Incident data described similar aspects with specific examples and clarification. The data sets individually and together reveal three aspects of student engagement leading to scopes and recommendations about enhancing student engagement in similar learning context.

Survey Results

We calculated the mean scores (the *arithmetic average* as defined by Fink, 1995) of the responses of survey statements (see Table 1). The results are interpreted in four chronological categories: low (1 to 1.99), average (2 to 2.99), modest (3 to 3.99), high (4 to 5).

The findings related to the behavioural dimension of engagement show a modest engagement of the students in active participation and attention in class activities as these were fairly motivating. The students perceived that the class greatly linked to their personal experiences. However, they did not find adequate opportunities to work with classmates, or even to ask questions for clarification or further information (see Table 2).

Table 2

Mean Scores of Behavioural Engagement

		Statement 1	Statement 2	Statement 3	Statement 4	Statement 5	Statement 6
N	Valid	32	32	32	32	32	32
	Missing	0	0	0	0	0	0
Mean		3.38	3.03	2.97	4.00	3.13	2.84
Std. Deviation		1.338	1.150	1.307	1.344	1.238	1.370

Data revealed a high level of students' emotional engagement in class activities as they thought those as relevant to future professions (Table 3). Their reflections showed a modest engaging environment in terms of a pleasant, motivational, target-oriented, and comprehensible learning situation.

Table 3

Mean Scores of Emotional Engagement

		Statement 7	Statement 8	Statement 9	Statement 10	Statement 11	Statement 12
N	Valid	32	32	32	32	32	32

	Missing	0	0	0	0	0	0
Mean		3.38	3.41	3.50	4.00	3.72	3.31
Std. Deviation		1.264	1.292	1.368	1.107	1.085	1.306

As to cognitive aspects, the students mentioned a modest level of engagement in areas including value and usability of learning, connection with the contents of other topics, and clarity of learning points (see Table 4).

Table 4

Mean Scores of Cognitive Engagement

		Statement 13	Statement 14	Statement 15	Statement 16	Statement 17	Statement 18
N	Valid	32	32	32	32	32	32
	Missing	0	0	0	0	0	0
Mean		3.00	3.59	3.28	3.72	3.50	3.94
Std. Deviation		1.295	1.388	1.486	1.143	1.391	1.216

To explore the linear relationship among the behavioural, emotional and cognitive dimensions of student engagement we also conducted the Pearson Correlation Coefficient test which is the Bivariate Correlation measurement. We applied five cut-off points: < 0.1: weak, < 0.3: modest, < 0.5: moderate, < 0.8: strong, > 0.8: very strong (Muijs, 2011). The findings show a very strong relationship among these three dimensions of student engagement (see Table 5).

Table 5

Correlation among Behavioural, Emotional and Cognitive Dimensions

		Cognitive	Behavioural	Emotional
Cognitive	Pearson Correlation	1	.973**	.922**
	Sig. (2-tailed)		.000	.000
	N	32	32	32
Behavioural	Pearson Correlation	.973**	1	.927**
	Sig. (2-tailed)	.000		.000
	N	32	32	32
Emotional	Pearson Correlation	.922**	.927**	1
	Sig. (2-tailed)	.000	.000	
	N	32	32	32

** Correlation is significant at the 0.01 level (2-tailed)

Critical Incident Questionnaire Results

The critical incident questions were theme-based, so the gained data explain the following five areas of student engagement. In our description, we have used the words *a few*, *some* and *most*, which represent about one-fourth, half and three-fourth of the total research participants respectively.

Most engaging moments. There were several highly engaging moments for the students in class. First, most of the students thought that they were highly engaged when they had the opportunity to work practically, such as while creating CSS pages, coding HTML, creating a website and solving the given worksheet. Some students also found a number of teacher activities engaging, for example, while the teacher explained and demonstrated the simulator tool, and instructed the procedures of uploading their work on server.

Least engaging moments. Most of the students mentioned that the beginning of the session was the least engaging moment for them. The teacher seemed to have a pre-assumed idea that all the students knew the basics of HTML which was not correct. A very few students found themselves engaged while the teacher was lecturing, particularly while introducing a new content. There was also a delay in some points, such as while distributing the passwords and at the time of uploading the work to server. Some students faced problems as too much information was given in the beginning. A few students also felt that the physical aspects of the classroom, such as room temperature and the seating arrangement at the back made them dis-engaged to learning activities.

Most helpful activity. Several teacher and student activities helped the programming students to be actively engaged in learning processes. The most engaging teacher activities were monitoring the student work, recapping the previous sessions, checking of student responses, and offering assistance when the students requested it. Some students also found the on-screen instructions and question-answer sessions engaging. Additionally, according to some students, the individual tasks with the worksheet and the discussion with their classmates for information and clarification were engaging.

Most confusing activity. More than half of the students did not find any confusing activity, either done by the teacher or students, in the class. Some however mentioned that the linking of two files in the simulator and the complex functioning of the simulator response editor were confusing as there was lack of direction and guidelines by teachers before and during their work. Yet, it was also thought by a few students that the reason for the confusion was themselves as they came in that class without required preparation.

Most surprising event. For most of the students the demonstration of the simulator, uploading the work on server and the HTML activity were surprising. They were also surprised as the class required several learning points to be remembered from the previous year. Some students were astonished as they found the teacher doing less teaching. Some students mentioned that the class was not a revision one, although it was supposed to be like that. A few students were amazed with the voting system using clickers which we used to conduct our survey in the classes.

Key Learning

The quantitative and qualitative data provided important explanations about student engagement in the programming class using a simulator. Among varied layers of student engagement (as explained by Fredricks et al., 2005), the study explored the levels of correlation of three dimensions, namely behavioural, emotional and cognitive, and identified a strong interrelated connection. According to this finding, if the engagement elements of any dimension change, there is a possibility that the other dimensions will change proportionately. It is therefore important in a programming class with a simulator to maintain proper quality of activities that can effectively contribute to students' behavioural, emotional and cognitive engagement in a balanced manner. As meaningful learning on programming depends on student engagement (Kujansuu & Tapio, 2004; Willingham et al., 2002), the findings indicate a possible high level of meaningful learning gains by students through engagement and participation. However, this finding does not confirm a similar trend in a low engaged class because other associated environmental factors, such as learning culture and the surrounding factors, may accelerate or hinder student learning gains there (Lawson & Lawson, 2013). Besides, the number of respondents was small, so in case of an increased number, these relationships may vary, even any of the dimensions may become more or less influential in student learning.

Teachers and educational resources play an important role in engaging students in learning processes (Davies et al., 2013; Mayer, 2002). In this study, a broad set of roles for teachers and students have been revealed that can help university faculty members design and facilitate more effective programming lessons using a simulator.

Firstly, we found that the use of a simulator can help teachers link learning contents with students' personal experience resulting an improved behavioural engagement. Students expect to share and collaborate in these classes and want to ask questions for clarification. Teachers, therefore, need to transform their lessons into inquiry-based and collaborative ones. The classes will then be motivating for students which is essential for their engagement in learning activities (Craft et al., 2008; Lawson & Lawson, 2013).

Secondly, from student perspectives, simulator-driven programming lessons are highly engaging as there is a connection with relevant professions and work. The students identified the learning environment less threating and more dialogic. These features along with student reflections and inquiry are essential for higher student engagement (Perkins et al., 1986). Students also opined that they became more engaged in their class when their teachers made lesson progression plans comprehensible and target-oriented.

Thirdly, this study shows that the students are keen on understanding the usability of their learning, and, according to the findings, a simulator-based programming class can supply this. In the process, they expect to discuss relevant issues and see an association of the content with other topics and subjects. Students also get engaged when the teacher ensures clarity of learning points and justifies the need for class activities.

Conclusion

This study provides evidence that the use of a simulator in programming lessons can improve student engagement for meaningful learning. The engagement would contain varied dimensions including behavioural, emotional and cognitive aspects, which need to be addressed in lesson planning and implementation. As the dimensions are interrelated, teachers need to be careful in addressing their individual elements in a proportional manner. They should also identify the lacks in any of these dimensions of engagement and can overcome the teaching and learning related drawbacks by exploiting other dimensions following systematic approaches. However, in our study we have not investigated the quality of student learning in this particular type of lesson; thus further investigation would be needed to understand the ranges of student learning gains along with the difficulties they face in achieving those. The future work is intended to look at the most suitable way to design simulation tools for learning and teaching programming topics.

References

Appleton, J. J., Christenson, S. L., & Furlong, M. (2008). Student engagement with school: Critical conceptual and methodological issues of the construct. *Psychology in Schools*, *45*, 369–386. doi:10.1002/pits.20303

Astin, A. (1985). *Achieving educational excellence: A critical assessment of priorities and practices in higher education*. San Francisco, CA: Jossey-Bass.

Brookfield, Stephen. (1995). *Becoming a critically reflective teacher*. San Francisco, CA: Jossey Bass.

Craft, A., Chappell, K., & Twining, P. (2008). Learners reconceptualising education: Widening participation through creative engagement? *Innovations in Education and Teaching International*, *45*(3), 235-245.

Darling-Hammond, L. (2010). *The flat world and education: How America's commitment to equity will determine our future*. New York, NY: Teachers College Press.

Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2013). Creative learning environments in education—A systematic literature review. *Thinking Skills and Creativity*, *8*, 80-91.

Eccles, J. S., & Wang, M. (2012). Part I commentary: So what is student engagement anyway? In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 133–145). New York, NY: Springer.

Fielding, N. G. (2012). Triangulation and mixed methods designs: Data integration with new research technologies. *Journal of Mixed Methods Research, 6*, 124-136.

Fink, A. (1995). *How to analyze survey data*. London, United Kingdom: SAGE.

Fredricks, J. A., Blumenfeld, P., Friedel, J., & Paris, A. (2005). School engagement. In K. A. Moore & L. H. Lippman (Eds.), *What do children need to flourish? Conceptualizing and measuring indicators of positive development* (pp. 305–21). New York, NY: Springer.

Fredricks, J. A., & McColskey, W. (2012). The measurement of student engagement: A comparative analysis of various methods and student self-report instruments. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 763-782). New York, NY: Springer.

Hedberg, P. R. (2009). Learning through reflective classroom practice. *Journal of Management Education*, *33*(1), 10-36.

Jenkins, T. (2002). On the difficulty of learning to program. In *Proceedings of the 3rd Annual Conference of the LTSN Centre for Information and Computer Sciences* (Vol. 4, pp. 53-58). Loughborough, United Kingdom: LTSN Centre for Information and Computer Sciences.

Johnson, R., Onwuegbuzie, A., & Turner, L. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research, 1*(2), 112-133.
Kahu, E. R. (2013). Framing student engagement in higher education. *Studies in Higher Education*, *38*(5), 758-773.
Krause, K. (2005, September). *Understanding and promoting student engagement in university learning communities.* Paper presented as a keynote address "Engaged, inert or otherwise occupied? Deconstructing the 21st century undergraduate student" at the *James Cook University Symposium 2005, Sharing Scholarship in Learning and Teaching: Engaging Students.* James Cook University: Townsville/Cairns, Queensland, Australia.
Kuh, G. D. (2009). What student affairs professionals need to know about student engagement. *Journal of College Student Development*, *50*, 683–706.
Kujansuu, E., & Tapio, T. (2004). Codewitz–An international project for better programming skills. In L. Cantoni & C. McLoughlin (Eds.), *Proceedings of EdMedia: World Conference on Educational Media and Technology 2004* (pp. 2237-2239). Waynesville, NC: Association for the Advancement of Computing in Education (AACE).
Lawson, M. A., & Lawson, H. A. (2013). New conceptual frameworks for student engagement research, policy, and practice. *Review of Educational Research*, *83*(3), 432-479.
Likert, R. (1932). A technique for the measurement of attitudes. *Archives of psychology, 140*(1), 44-53.
Mayer, R. E. (2002). Rote versus meaningful learning. *Theory into Practice*, *41*(4), 226-232.
Muijs, D. (2011). *Doing quantitative research in education with SPSS* (2nd ed.). Thousand Oaks, CA: Sage.
Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students*: *A third decade of research, Volume 2*. San Francisco, CA: Jossey-Bass.
Perkins, D. N., Hancock, C., Hobbs, R., Martin, F., & Simmons, R. (1986). Conditions of learning in novice programmers. *Journal of Educational Computing Research*, *2*(1), 37-55.
Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research*. Thousand Oaks, CA: Sage Publications.
Trowler, V., & Trowler, P. (2010). *Student engagement evidence summary*. York, United Kingdom: Higher Education Academy.
Willingham, W. W., Pollack, J. M., & Lewis, C. (2002). Grades and test scores: Accounting for observed differences. *Journal of Educational Measurement*, *39*(1), 1-37.

Author Details

Olufemi Isiaq, PhD
femi.isiaq@solent.ac.uk

Md Golam Jamil, PhD
md.jamil@solent.ac.uk