Exploring Global Thinking and Team-based Reflection in a Flipped Classroom

Rune Hjelsvold, Amund Sørumshagen
Department of Computer Science
NTNU

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Abstract

Research suggests that student may perform better when the classroom is flipped, the students work in teams, and the students are taught in a global manner. A project was therefore initiated to explore the integration of global thinking and team-based reflection in a flipped classroom. In the project, we investigated how well students prepared at home, how well they worked in teams, how students worked, and how well they performed in the final exam in such a setting. The main lessons learned were that the students did not do as much at-home preparation or at-school collaboration and reflection within the teams as expected. There was no observable improvements to the students' exam performance either. This paper discusses possible reasons for not achieving the expected results and may give useful input to researchers designing other, similar projects.

1 Introduction

Educators are faced with the challenges of organising engaging and motivating learning activities to an ever-changing population of students – within the constraints of available resources. Computer science educators have the benefits of being in a field where it can be relatively easy to add a number of different lab, project, and other hands-on activities to complement the traditional, passive form of lecturing. In many cases, however, the combination of lectures and lab exercises/projects does not seem to be sufficient to motivate students to work as much and as hard as intended. Lecture attendance is dropping throughout the semester and students push lab exercise work until the very deadline for handing in the lab report.

In their work on learning and teaching styles in engineering education, Felder and Silverman [4] discuss the mismatch between the teaching style chosen by the educators and the learning styles preferred by many students. Felder and Silverman recommend creating "learning processes of active experimentation and reflective observation" to better meet the students' preferences. Alshammari et al. [1] show that computer science students may have better learning gains when learning is adapted to the *intuitive-sensory* dimension. Felder and Silvermann anticipate that many engineering students would

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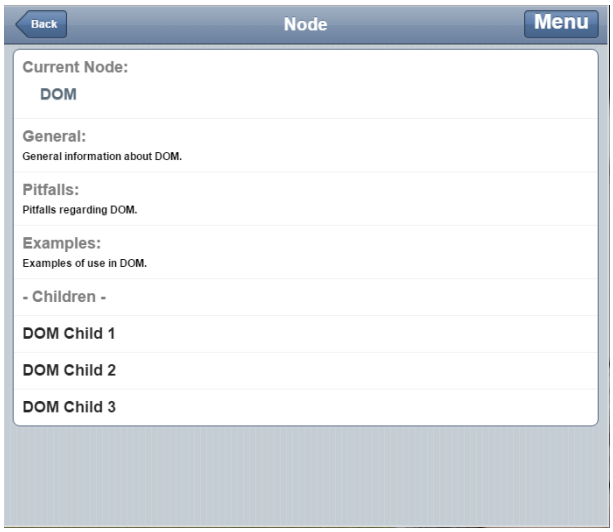

Figure 1: Screen Dump of the XML Tool

benefit from also considering the *global dimension*, i.e., drawing the bigger picture too, rather than only presenting material sequentially in "small pieces". Felder and Silverman describe the global learners as a potentially important group of engineers:

> They are the synthesizers, the multidisciplinary researchers, the systems thinkers, the ones who see the connections no one else sees. [4]

This paper describes a limited project run within an introductory database course trying to address these challenges. The course is normally run as a combination of ordinary lectures and a sequence of six two-week lab exercises. The aim of the project was to see if flipping the classroom and – at the same time – encouraging global thinking and collaborative learning and reflection would make an impact on the students' motivation and work habits. The course module on XML – lasting for two weeks in total – was flipped, the rest of the course was taught in the traditional way. The project was conducted as a master thesis [9] at the former Gjøvik University College.

The elements of the project were:

- **Flipped classroom:** Regular lectures were replaced by short video recordings that students were expected to watch before coming to campus. The lecture hours were used for group work were the lecturer and the teaching assistants were present.
- **Global thinking:** Each team created a joint wiki defining and describing the core XML concepts in a top-down manner. The wiki should include examples of actual use of these concepts and should summarise main challenges and common errors.
- **Team-based collaboration and reflection:** The students were expected to contribute to the teamwork by creating wiki content individually at home. A custom XML wiki authoring tool was developed to support students in reviewing and reflecting on the various team member's contribution. The tool made it easy for the group to include team member contributions into the group wiki. The teams should thereby benefit from the team members' at-home preparations. Figure 1 shows the dump of the screen for entering information about an XML concept.

There are other projects investigating various forms of flipped classrooms and collaborative learning, e.g., [6] and [3], but projects tend to be small and inconclusive.

Our project was therefore aimed at exploring other potentially promising approaches. The research questions we addressed in the project were:

1. Will having individual at-home preparation for group work motivate students to prepare for the at-school group sessions?
2. Will a global approach combined with collaborative learning and reflections have an impact on work habits?
3. Will a global approach combined with collaborative learning and reflections improve learning outcome?

The project did not turn out to be successful - i.e., the students motivation, work habits, or learning outcome did not change much. The authors still believe that this paper will help us – as a community of lecturers and as a community of researchers in computer science education – to advance our understanding of how students may respond to changes in the way a course is being taught and our understanding of what course designers should take into account when designing for new learning activities.

This paper will first summarise relevant theories and projects. It will then describe how the learning activities were organised in the flipped classroom to encourage participation, global thinking, and team-based collaboration and reflection, followed by a presentation of the observations that were made and the results that were achieved during the project. At the end of the paper, the results are discussed, conclusions are drawn, and suggestions for further work are outlined.

2 Background

Our decision to run a study on exploring global thinking and team-based reflection in a flipped classroom was based on research done in the areas of learning styles, flipped classroom, and collaborative learning. This section gives a short introduction to some of this research.

Global thinking

Felder and Silverman [4] have identified five dimensions of learning styles:

- sensing–intuitive,
- visual–verbal,
- inductive–deductive,
- active–reflective, and
- sequential–global

Four of the five dimensions are part of the ILS questionnaire[1] that students can use to find the characteristics of their personal learning style. As mentioned earlier, Felder and Silverman identified a mismatch between many engineering students' global perspective and the lecturers preference for a sequential teaching style. Al-Saffar [8] did a study among computer science students suggesting that male computer science students have a tendency towards being more global learners and female computer science students even more so.

[1] `https://www.webtools.ncsu.edu/learningstyles/`

Flipped Classroom

Baker[2] was possible the first one to suggesting a "classroom flip". The goals of such a flip should be to:

1. Find an approach that would make it possible for faculty to move from sage to guide.
2. Reduce the amount of time spent in class on lecturing, opening up class time for the use of active learning strategies.
3. Focus more on understanding and application than on recall of facts, while not sacrificing presentation of factual base.
4. Provide students with more control over their own learning.
5. Give students a greater sense of responsibility for their learning.
6. Provide students with more opportunities to learn from their peers.

Giannakos et al. [6] has compared 32 studies on flipped classrooms. They identified six main benefits of the flipped classroom:

- Increases Learning Performance
- Positive Attitudes
- Increases Engagement
- More Discussions (Qualitatively Measured)
- Enforces Cooperative Learning
- Better learning habits

There is also research suggesting that the student performance is improved in a flipped classroom, compared to unflipped teaching. Gopalan et al. [7], for instance, found that this was true of students in both the upper and lower half of the class. Furthermore, there is research suggesting that class attendance in a flipped classroom with collaborative learning has a positive impact on the students' performance. Foldnes [5], for instance, found ´´a substantial effect of class attendance on student achievement"

Collaborative Learning

Zheng et al. [10] did a study on using wikis for collaborative learning and concluded that:

> students expressed a generally positive attitude towards the use of wikis to improve their collaborative learning, transform learning from teacher-centric to student-centred learning and support their content knowledge learning.

In a different study, Caceffoet et al. [3] investigated the differences between lectures on the one hand and problem-based learning and peer instruction as more active learning approaches to computer science classes. Their study found that problem-based learning was considered more learning and more motivating by the students than peer instruction.

3 Organising the Flipped Classroom

The Flipped Classroom Session

Traditional lectures were replaced by team-based work session during this experiment. Short videos were created and the students were instructed to watch these videos, use their textbooks, and/or use other material outside lectures to prepare for group discussions. Rather than attending lectures, the participants attended group sessions discussing XML basics and creating a wiki presenting their common understanding of the content in a global perspective. Recommended group size was 3-4 students. The course lecturer attended the discussions and provided guidance if requested. Students had to use a web application which was created for this experiment to create their common content.

The Task

In addition to the group activities mentioned, the students could also create individual content in the web application. The intention behind this was to motivate students to prepare for group sessions by bringing their own thoughts regarding the content, and by collaborating and reflecting in class to agree on joint group content. The individual activities were not mandatory, but recommended from course lecturer as preparation for in-class activities. The only mandatory assignment was to create group content and this was assessed by the course lecturer.

The Tool

A web application was developed to support the intended research objectives in this experiment. The application tried to present a global approach to learning by making it possible for the students to create trees from the content. By making the students create a hierarchically structure from the content, identify main points and place other parts in relation to the ancestors, we hoped this would add a different perspective to the material.

Each student had their own individual log-in, and the possibility to create their own individual tree for preparation. The intention behind this feature was to give the students the possibility to prepare for the group sessions and also motivate students by offering something else than the traditional textbooks or other written content.

Finally, in the group sessions the group used the application to create a common tree which was the only mandatory assignment in this experiment. This delivery was to be assessed by the course lecturer.

The Work Process

Several activities were conducted by the researchers to gather data from this experiment. First, a pre-questionnaire was completed prior to the experiment. The aim of this questionnaire was to record student motivation and opinion before participation. Second, a post-questionnaire was completed after the experiment. The aim of this questionnaire was to monitor changes in motivation and opinion during and after the experiment. In both questionnaires the students had the possibility to add comments to each question. The questionnaires ranged from one to five: Strongly disagree(1), Disagree(2), Neutral(3), Agree(4) and Strongly Agree(5).

Thirdly, observations were made during in-class sessions throughout the experiment to monitor group dynamics and get an idea of how group members were working together. Fourth, in-depth interviews were conducted with four of the groups after completing the experiment. This provided qualitative perspective on the experiment and learning

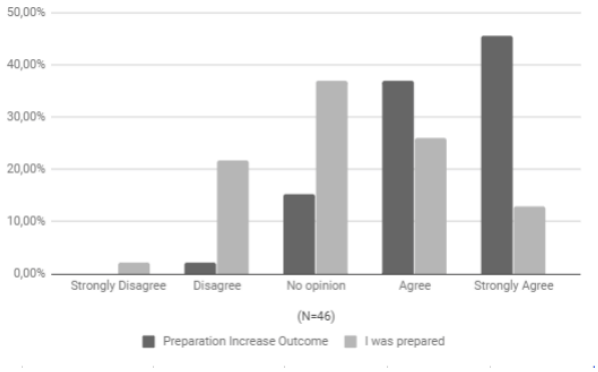

Figure 2: Preparation will Increase Outcome / Students was Prepared

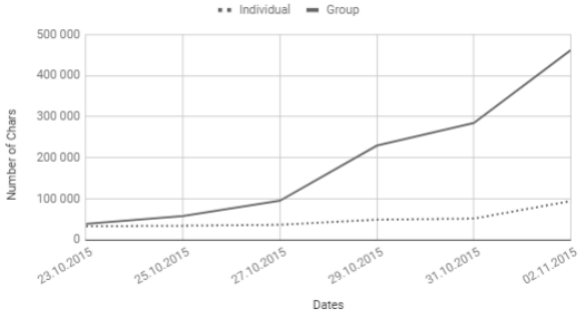

Figure 3: Number of Characters Produced by Individuals and Groups

activities. This was organised as a semi-structured interview where students could share anything related to the questions asked or the activities in general. Fifth, production logs were collected from the tool developed. Every other day, the number of nodes created and the total number of characters were collected. The collection included both the individual trees and group trees, and the goal was to see if: 1. Individual students used the tool in preparation, and 2. How both individuals and groups distributed the workload during the two-week session.

4 Results

Students' at-Home Preparation

When the experiment period was completed, students were asked if they believe that at-home preparations will increase learning outcome, and if they were prepared coming to the in-class group sessions in this experiment. Figure 2 show that 39% of the students indicate that they came prepared, while 83% of the students believe that being prepared will increase learning outcome.

Students' Perception of Global Thinking and Reflections

Production logs from the XML tool where recorded; the number of nodes and the number of characters produced from individuals and groups were logged. Figure 3 show that the workload distribution increased towards the end of the experiment and the delivery deadline.

In the pre-questionnaire, students were asked if lecturers should aim at presenting the content into a wider context, while the post questionnaire asked if assignments should help

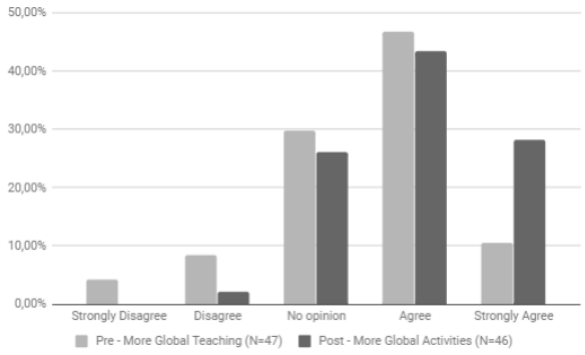

Figure 4: Global Perspective in Teaching

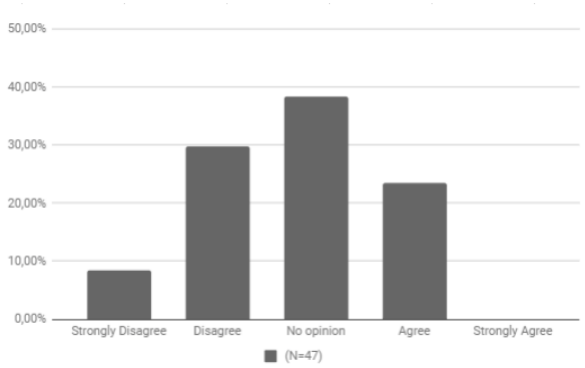

Figure 5: Sufficient Time for Reflection in Teaching

give a better understanding on the big picture. Figure 4 show that before the experiment, 57% believe a more global perspective in teaching would be useful, while in the post questionnaire, 72% answered that assignments to achieve a wider understanding, and comments also suggests it would help them prepare for working in industry after school.

The pre-questionnaire also asked if students believe there is enough time for reflection work in traditional teaching. Figure 5 shows that 38% of the students are not satisfied with the time set aside for reflection teaching.

Impact on Learning Outcome

The final marks from the course were compared to the next-year cohorts where the course was taught in the traditional way. Both the final marks from the course in total, and the particular exam questions from the XML topic were compared. Figure 6 show distribution of final marks from the course achieved by the experiment group compared to the next-year cohorts. As shown in the figure, there is no significant difference in scores between the two cohorts. Figure 7 show the marks related to the XML part of the exams (constituting 25% of the total exam score). The figure shows that there are no big differences between best performances in the two cohorts. There is, however, a somewhat larger difference between the weakest performances in the two cohorts with nearly 10% more students failing in the flipped classroom cohort.

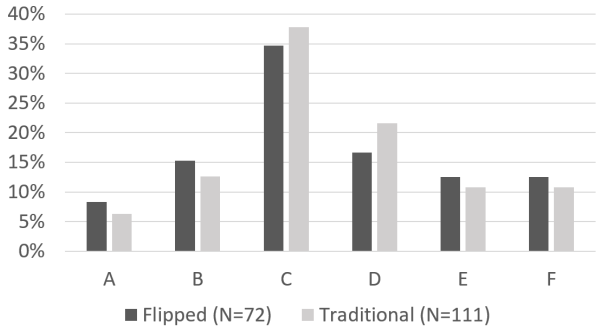

Figure 6: Distribution of Final Marks

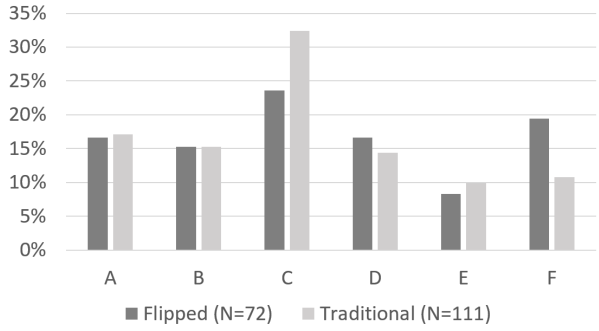

Figure 7: Distribution of Marks on the XML Part

What could have been Improved

Students were also asked how the felt about using the XML tool in this experiment, and if they feel that a tool to give a specific outcome can work. 30% of the students experienced this specific tool as a disturbance. On the other hand, 67% believe that a tool to give a specific outcome can work, and no one disagreed on this.

5 Discussion

In this section we will discuss the achieved results in relation to our research questions.

Students' at-Home Preparations

Our first research question was to see if students would be more motivated to do the at-home preparation work when the results of their home sessions could be directly used in the at-school sessions as part of the teams' contributions. The results, however, show that only 39% of the students indicate that they did prepare well before coming to the at-school group sessions - even though 83% reported that preparing for class would increase learning. Several students mentioned that the value of the team-based reflection was greatly reduced when team members had not prepared properly for the team-based sessions.

One of the reasons for lack of motivation for preparing at home may be that only a few students found working on a wiki as motivating. Several students commented that they would rather have developed a software system than creating a wiki.

Students' Perception of Global Thinking and Reflections

Our second research question was to see if a global approach combined with collaborative learning and reflections would have an impact on work habits. The results, however, show that school session attendance dropped approximately 20% during the project. The results also show that the groups' production was much higher during the last couple of days of the project than during the rest of the project (the average production during the last two days, for instance, was about four times higher than the average production during the six days prior).

Our results do, however, indicate that our project increased the students' awareness of global thinking. 57% of the students reported that they would like to see more activities where they could put their contributions into a wider context. This increased to 72% at the end of the project.

In the pre-questionnaire, 38% of the students indicated that too little time is set aside for reflection in teaching in general. Observations and interviews, however, suggest that only a few of the teams did spend the group time in reflecting. One reason for this may be that the only some students did prepare for the group sessions as intended and that many groups divided the work among the team members rather than reflecting on individual solutions to the various tasks.

Impact on Learning Outcome

Our third research question was to see if a global approach combined with collaborative learning and reflections could improve learning outcome? The exam results do not indicate such an improvement when compared to the next-year cohort where the XML part of the course was taught in the traditional way. The students' score on the XML exam questions (the topics covered in the flipped classroom project) in the two years are quite similar except that approximately 10% fewer students got a C on this part while approximately 10% more students got an F. The results may thus suggest that flipping the classroom the way we did, did have an impact on the best students but had an negative impact on the weaker ones. One should be aware, though, that these were two different cohorts attending the course in two different course years. There may therefore be other reasons for the differences even though the distribution of grades in the two cohorts were quite similar.

What could have been Improved

In retrospect, we do see improvements that could have been made to our setup:

- It was too easy for the teams to divide the work among team members and thereby reduce the per student workload but also reducing the amount and quality of group discussions. More group reflection could have been achieved if the tasks required tighter collaboration among the team members.
- Students did not find the task of constructing a wiki of XML motivating. The student feedback indicates that some development work would be more motivating to the students and could therefore result in students spending more time - individually as well as group-wise.
- Students did not find the XML wiki tool useful. The tool was supposed to increase the value of the at-home preparations by directly supporting global thinking and at the same time enabling the students to bring their contributions directly into

the group work. 30% of the students, however, found it to be a disturbance in their group work. Other, common collaboration tools may have supported the team interactions better.

- The flipped classroom project was announced in due time before it started. The setup, the tasks, and the tool to be used was presented to the students in lectures prior to the experiment. Still, only 46% of the students responded that they thought the flipped classroom session was well presented. This issue could have been addressed by having a short discussion at the end of the first at-school group sessions for questions and reflections on the flipped classroom setup and on global thinking and team-based reflections.

Limitations of the Study

In this study, we have used a mix of methodologies, qualitative as well as quantitative.

- Pre- and post-questionnaires: Less than 64% of the students participating in the exam did answer the questionnaires and may therefore be skewed.
- Observations: The observations were done in a quite informal manner, not following a specific protocol.
- Interviews: Students interviewed were chosen among the ones showing up for the at-school group sessions - which less than 70% did.
- Production logs: These logs show the number of characters entered and nodes created in the system and do not show what students produced elsewhere.
- Exam results: Comparing the results achieved by two different cohorts of students solving different exam questions is susceptible

6 Conclusion and Further Work

Research suggests that flipping the classroom may increase active learning and learning from peers (Baker [2]) and improved engagement and better learning habits (Giannakos et al. [6]). Research also suggests that students may have a positive attitude towards the use of wikis to improve their collaborative learning (Zheng et al. [10]). In our project, we combined the ideas of flipped classroom, collaborative learning, and the use of wiki to achieve improved global thinking, student motivation, attendance, and total work efforts. The answers received to a pre flipped classroom session questionnaire indicate that a significant number of students would like to see the curriculum placed in a wider context than usual, to have more time for shorter groups assignments, an more time for reflection in teaching. The data that we collected through observations, feedback from students, and exam results, however, does not indicate that flipping the classroom resulted in improved motivation for at-home preparations, for attendance, or for learning:

- Observations show that some student groups worked as intended but also that attendance rate was dropping during the project and that students still worked more towards the deadline than at the first half of the flipped classroom session.

- Questionnaires answered by the students show that they would like to see more opportunities for interaction and for global thinking, but only 52% of the students felt that the flipped classroom structure gave a good overview and only 39% thought that working on a wiki was a good way to practice global thinking. Only 39% of the students reported preparing well at home before the group sessions. Only 28% of the groups saw all team members working on all topics.

- Interviews indicate that the students did not find creating a wiki as a motivating group activity.

- Exam results were comparable to those achieved by the next-year students doing a non-flipped version of the course. There was, however, a slightly higher failure rate for the flipped classroom students.

It his hard, from the data we collected in various forms, to conclude what could have been done to achieve improved global thinking and team-based reflection in the flipped classroom. The observations, student interviews, and long questionnaire answers, still give us a basis for reflecting on what could be done to improve the outcome of our way of flipping the classroom:

- The flipped classroom project was only a small part of the course - lasting for two complete weeks. Some students mentioned that they did not fully understand the setup or the activities at the very beginning. It got clearer only as they had worked together for some time. We think that we should have spent more time – before and during the classroom sessions – for meta discussions, i.e., for discussing and reflecting on the learnig activities as such.

- Several students found that team-based reflection was useful - but only if the team members had done the at-home preparations and thereby really could contribute to the discussion. Some students argued that the amount of at-home work required was the reason why students decided to split the topics among themselves rather than having all students prepare for all the topics. We think that we should have spent more time and efforts sizing the flipped classroom tasks to make sure that more students could find the time to prepare the way we intended. We also think that we should have spent more time creating tasks that would encourage collaboration and discourage students from splitting tasks among the team members.

- Some students commented that they would prefer working on a development project rather than on creating a wiki. We might have experienced the students being more motivated and working harder if the flipped classroom tasks were to develop an XML solution rather than creating a wiki for presenting XML technologies.

- Some students thought that the global perspective should have been even wider than just within the area of XML; it should preferrably link to larger, real-world systems. We might have experienced more motivated students and improved learning if the flipped classroom tasks had been better framed in the context of large, real-world systems.

Beyond these, one clear response we got from the students is that they would like get more assistance in seeing the “bigger picture”. They would like to see course topics being part of a larger picture and would like to get more practise in working on larger

systems. In one of the interviews, for instance, one of the students stated that she got more of a global view from her part-time job in industry than from the university courses. Therefore, future work on how to link detailed learning activities to the "bigger picture" would be helpful to our computer science students.

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