AN EXPERIENCE USING TEAM RULES FOR IMPROVING TEAM WORK IN SOFTWARE ENGINEERING UNDERGRADUATE EDUCATION

Daymy Tamayo Avila¹, Wim Van Petegem²

¹ University of Holguin (CUBA)
² KU Leuven (BELGIUM)

Abstract

Modern software development involves intensive team work. Consequently, it is required to pay more attention to collaborating in team in software engineers’ education. Cohesion is considered a human factor impacting team effectiveness in general [1]. Some authors have been researching team cohesion in software engineering. It has been found that team cohesion is an important human factor in the establishment of a motivating working environment in software organizations [2], with significant positive effect on the productivity of developers [3], [4] and on team performance [5]. Despite cohesion is recognized to play an important role by not only the corporate but also the academic world [6], [7], scarce evidence exists about team cohesion as taught in software engineering education.

This work shows the results of a pilot study related to cohesion and its relationship with performance behaviors in undergraduate software engineering education. The students’ teams were involved in software projects in industry. Teams had to agree on rules with regard to communication and conflict management pursuing more cohesive teams. It was observed that the level of cohesion was related to team performance behaviors. Students’ perceptions of the member contributions related to behaviors for several levels of performance were used as a feedback in order to update the initial agreements on team rules. The study was deployed in Cuba during a software engineering course.

Keywords: Team work, software engineering education, cohesion, performance behaviors.

1 INTRODUCTION

In a highly interconnected and interdependent world, with problems more complex and engineering becoming of a more global nature, engineering education calls for a more holistic approach. Solving societal and engineering challenges today implicates team-based, cross-disciplinary projects in which different engineering disciplines are involved and social and human factors become more important. Software engineering (SE) activities are essentially cooperative and are performed by teams [8]. Modern software engineering products require a high level of quality, but also overcoming schedule and budget constraints. However, famous Chaos Reports show that software project success is around 30% [9]. It has been stated that when software projects fail generally it is more because of teamwork problems than technical issues [10]. This research showed that for typical large software projects team working is about 70% of the time allocated to the project. Nowadays this could be even higher because of the general use of agile methods by the software community trying to overcome project constraints, which are focus on cross-functional teams empowered [11].

The ability to work as an effective member of a development team is a primary goal of engineering education [12] and is also included in the ABET students’ learning outcomes criteria for accrediting computer programs [13]. Team work is also included in the Curriculum Guidelines for Undergraduate Degree Programs in Computer Science [14]. A recent search on the web of science using TS= ('software engineering education' and team*) shows 133 papers, most of them published in the last 5 years. This confirms that teams have been a research object with substantial attention. Several aspects of team working in software engineering have been studied. In particular, some authors such as [15], [16] focus on studying team performance. Several measurements have been used, and in general, emphasis is put on the process results rather than on the behaviors that allow software engineers to obtain team objectives. Cohesion is considered as one of the most important factors that influence software teams. However, it has been scarcely studied in software engineering education and there is not empirical evidence on the relationship with team performance behaviors.

This work presents the results of a pilot study on software engineering team working at undergraduate level. The remainder of this paper is structured as follows: Section 1 describes the methodology used
to guide the study. Section 2 refers to the method of intervention and the results of the pilot experiment. Section 3 concludes the paper.

2 METHOD

2.1 Participants
Sixteen software engineering undergraduate students participated in the study from the University of Holguin. They were all also developers at Datys Company in Cuba performing in three teams of five or six members. Out of the participants, (69%) were male; (31%) were female. Their age levels ranged from 22 to 28 years old. They had between two and five years of experience in team work after college graduation.

2.2 Course
The course was on Software Engineering Management. It included topics about project and team management with a focus on agile methodologies. The learning activities in the course were related with the projects they were doing at the company. All the projects were guide by Scrum software methodology.

2.3 Variables
Team cohesion is considered the independent variable. For the purpose of this study we go back to the conceptualization of [17], applied by [18] to software engineering students. In their vision cohesion can be thought of in two very different ways: the social attachment within the team and the team’s connection to the project itself (calling these social ‘S’ and task ‘T’); and at two levels of granularity: at the individual level and for the team as a whole (calling these Individual Attractions to the Group (IAG) and Group Integration). The combination of these two dimensions and different levels result measures in four aspects of team cohesion:

- GI-T: The team’s attachment to the task
- GI-S: The team’s social connection
- ATG-T: Individual attachment to the task
- ATG-S: Individual connection to the team

Team performance is studied here as the dependent variable seen as behaviors related to the tasks and team learning. Team performance is usually measured with indicators for effectiveness and efficiency. However, [1] differentiated between performance behaviors and performance outcomes. Team performance behaviors are actions relevant to achieving goals, whereas outcomes are the consequences or results of performance behaviors. In this study we define team learning behaviors as the ‘activities carried out by team members through which a team obtains and processes data that allow it to adapt and improve’ [20]. Performance on task is assessed as the degree in which the team satisfies client needs and expectations. Team performance behaviors variable is measured then in two aspects ‘Team Performance Behaviors on Task’ and ‘Team Learning’.

2.4 Method of intervention
As can be seen in Figure 1, the intervention by the teacher on the teams consisted of three phases over a period of ten weeks. In the first week, an individual diagnosis on team working skills was done with a Team Knowledge Test (TKT) questionnaire, used by [21] to survey software engineering students. At that time, team cohesion and performance behaviors were measured as well. In order to measure the variables, questionnaires proposed by [17] and [20] were used, slightly adapted to educational settings. A 5-point scale, from “strongly disagree” to “strong agree”, was used.
The training on team working skills was based on a role playing strategy and it was focusing on communication and conflict management. In order to identify different roles, students were asked to fill in the Belbin questionnaire [22]. Software engineering roles like analyst, programmer, tester and client were also used. Conflict situations were simulated by providing software artifacts and project documents such as a product backlog, list of requirements and sprint planning. Students had to solve those situations playing different roles.

Students evaluated the functioning of their teams using the Team Process Checks questionnaire [23]. Using that information and based on lessons learnt from the team working training and their individual diagnosis, they were asked to agree on team rules. The rules were about communication and conflict management. Students continued their team work for five weeks under these team rules. After that they were asked to self- and peer-evaluate team member contributions. This information assisted as a feedback to update the rules. Team member contributions were evaluated on five areas, according to three levels of team performance behaviors, using the questionnaire proposed by [24]. The areas include contributing to the team's work, interacting with team mates, keeping the team on track, expecting quality and having relevant Knowledge, Skills, and Abilities (KSAs). After ten weeks, all variables were measured again.

3 FINDINGS

The overall value for each variable is shown in Table 1, averaged over the three teams, before (first week in the study) and after the intervention (at the end of the study). Team performance behaviors variable is considered as the sum of team performance on task and team learning. In the third column is presented the delta, and in the last column the p-value after performing a t-student test (using SPSS 20.0).

<table>
<thead>
<tr>
<th></th>
<th>X Before</th>
<th>X After</th>
<th>X Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohesion</td>
<td>3,28</td>
<td>4,00</td>
<td>0,72</td>
<td>0,00</td>
</tr>
<tr>
<td>Team Performance Behaviors on Task</td>
<td>3,96</td>
<td>4,18</td>
<td>0,22</td>
<td>0,00</td>
</tr>
<tr>
<td>Team Learning</td>
<td>3,88</td>
<td>4,57</td>
<td>0,69</td>
<td>0,00</td>
</tr>
<tr>
<td>Team Performance Behaviors</td>
<td>3,96</td>
<td>4,38</td>
<td>0,42</td>
<td>0,00</td>
</tr>
</tbody>
</table>

As can be seen, the overall value for all variables has incremented after the intervention. Team performance behaviors regarding with team learning incremented more than performance on task. Team cohesion has also increased substantially after the intervention. A further analysis was made
then to clarify the mechanisms explaining why cohesion improved, addressing each of the two
dimension at both the individual level of granularity and for the team as a whole. Results of this
analysis are shown in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>X Before</th>
<th>X After</th>
<th>X Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATG-S: Individual connection to the team</td>
<td>3.59</td>
<td>3.88</td>
<td>0.29</td>
<td>0.003</td>
</tr>
<tr>
<td>ATG-T: Individual attachment to the task</td>
<td>3.03</td>
<td>4.10</td>
<td>1.07</td>
<td>0.000</td>
</tr>
<tr>
<td>GI-S: The team's social connection</td>
<td>3.39</td>
<td>3.79</td>
<td>0.39</td>
<td>0.000</td>
</tr>
<tr>
<td>GI-T: The team's attachment to the task</td>
<td>3.08</td>
<td>4.23</td>
<td>1.14</td>
<td>0.000</td>
</tr>
</tbody>
</table>

From Table 2 we learn that the levels of the different dimensions of team cohesion had dissimilar
changes. The improvement was seen especially for the dimension ‘team’s connection to the project’
and less for the ‘social attachment to the team’ dimension.

4 CONCLUSIONS

The pilot study in software engineering undergraduate education presented here shows that team
rules on communication and conflict management improve team cohesion, which leads to more
effective team performance behaviors. These results are consistent with previous research that
appointed communication [25], [26] and conflict management [27] as key factors to improve team
cohesion, and team rules important for student team work in higher education [28]. This is also in line
with the findings of the meta-analysis by [19], that showed strong correlation between cohesion and
team performance behaviors. As the results showed dissimilar improvement in the different
dimensions of team cohesion, future work will explore the influence of other factors closely related to
the social dimension of cohesion, such as personality types [8], [27] and team formation [29] for co-
located software teams.

REFERENCES

of Recent Advancements and a Glimpse Into the Future,” J. Manage., vol. 34, no. 3, pp. 410–
476, 2008.

coding industrial practice : A cross-case analysis of two software organisations,” Inf. Softw.


[4] Q. Xuan, H. Fang, C. Fu, and V. Filkov, “Temporal motifs reveal collaboration patterns in online

Software Development : Research versus Current Advice,” IEEE Softw., vol. 33, pp. 106–110,
2016.

2014.


methodology on cohesion in software engineering teams,” Behav. Inf. Technol., vol. 26, no. 2,


