How to Do IT Together: Modeling Group Work for Information Technology

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ABSTRACT

Students of programming need to master group work skills. This paper presents a model for group work in it classrooms based on literature and research done the past couple of years. The model emphasizes the importance of structuring small group work for effectiveness by ensuring that the basic elements of positive interdependence, individual accountability, face-to-face interaction, interpersonal and social skills, and group processing are correctly applied. Assigning particular responsibilities to group members and assessing groups are also addressed. A description of the research methodology and data collection and analysis techniques to be used in the piloting of the model is provided. We describe the training workshops for teachers used, the actual teaching of the model in these teachers' classrooms, as well as future work envisioned. Finally, the importance of the study is justified and conclusions drawn.

CATEGORIES AND SUBJECT DESCRIPTORS

K.3.1 [**Computers & Education**]: Computer Uses in Education - *Collaborative learning.* K.3.2: Computer and Information Science Education - *Computer science education, Self-assessment.*

GENERAL TERMS

Management, Experimentation, Human Factors.

KEYWORDS

Group work, Information Technology.

1. INTRODUCTION

"Information (T)echnology projects are growing in complexity" and size [17]. These days, not only can "(t)eam experiences … be important learning experiences," [9] but, indeed, "(t)eamwork (have become) essential for software development" [7], "and industry highly values team skills in graduates." [9].

In order for Information Technology (IT) students to be responsive to these changing requirements of the workplace, while learning programming, they must also develop the necessary social skills. In the IT education milieu, various forms of group learning have been widely researched [1]. These important teaching-learning strategies produce increases in learning skills, improve student motivation and have significant positive effects on student performance and attitudes towards instructional content [1,4]. Many of these advantages also represent transferable skills that influence the ways in which students go about their learning tasks - not only when working together in groups, but also when learning individually.

"(G)roup-based … cooperative learning has many benefits to individual student learning" [6]. [13] refer to "(r)esults (which) suggest that cooperative learning with … students can lead to greater cognitive involvement, somewhat greater activation, and higher levels of motivation, including higher engagement, greater perceived importance of the tasks, and more optimal levels of challenge in relation to skill." [17] believe that during the process of actively thinking and working together to construct problem solutions, group projects "provide students with an opportunity to share (and explore) ideas, learn new concepts, expose different points of view, and experience the satisfaction and challenges of working with others". "(S)tudents felt that group work is a method that significantly fosters the development of a wider breadth of knowledge through discussion, clarification of ideas; and evaluation of others' ideas." [6]. Exposure to these kinds of opportunities encourages students to work together well - regarded as to be one of the characteristics promoted by good teachers.

Given the many advantages detailed above, it is, however, vital to appreciate "how teachers may influence small-group interaction." [19]. "(I)t is imperative that … teachers understand how to structure and monitor meaningful learning experiences for students" [13], that lead to the type of thinking and problem solving that is necessary to involve them in the learning process [4]. Research referred to by [3] demonstrates the need for training teachers in the development and implementation of group learning skills. Such training not only

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adds to the advantages of this instructional approach, but also empowers teachers to help their students in the IT classroom to utilize group work skills effectively.

Research as detailed above demonstrates the learning benefits of group work and shows how it can be a valuable teaching strategy in the IT class. Despite this evidence, we found that it is not commonly used for teaching IT [11]. There is still a strong tendency among teachers to depend on individual teaching strategies for teaching programming skills, favoring individual problem solving and individual practice of programming skills. The research question that will therefore serve to focus this paper is: How can group work be meaningfully integrated into the teaching and learning of programming skills?

For the remainder of this paper, we start our journey towards a model for group work in IT classrooms by offering a literature survey of the essential components of effective group work, and results obtained from our own research on this matter. We then explain how the basic elements of positive interdependence, individual accountability, face-to-face interaction, interpersonal and social skills, and group processing should be structured for small group work to be effective. Assigning particular responsibilities to group members and assessing groups are also addressed. A description of the research methodology and data collection and analysis techniques to be used in the piloting of the model is provided. The piloting of the model in terms of the training workshops for teachers used, the actual teaching of the model in these teachers' classrooms, as well as future work envisioned, are described next. Finally, we present an indication of the importance of the study, and offer the conclusion.

2. LITERATURE SURVEY

2.1 Essential group work components

Those experienced in the use of group work know that simply "placing students in groups and telling them to work together will not necessarily promote cooperation and learning" [3]. Literature (see e.g. [8]) emphasizes the importance of structuring small group work for effectiveness, by ensuring that the following essential components are evident:

1. **Positive interdependence**: "individuals believe they are linked with others so they cannot succeed unless the others do" [8]
2. **Individual accountability**: "each collaborator must be individually accountable to do his or her fair share of the work" (ibid)
3. **Interpersonal and social skills** "such as leadership, decision making, trust building, communication, and conflict management skills" (ibid)
4. **Face-to-face interaction**: group members "must have the opportunity to promote each other's success by helping, assisting, supporting, encouraging, and praising each other's efforts to achieve" (ibid), and
5. **Group processing**: "group members discuss how well they are achieving their goals and maintaining effective working relationships." (ibid).

As was the case for [13], group learning activities in this model was designed to encompass the basic elements of group learning as described above.

2.2 Our previous research

In the first piece of our own previous research that we based this model on, we "discussed teachers' perception of the use of group work in the IT classroom" [11] by describing "the current situation regarding the implementation of group work in IT classrooms in South Africa, as well as the challenges that IT teachers face when implementing group work." (ibid). Teachers' responses indicated that they "did not seem to appreciate the dynamics of group work and the contribution that group work could make to effective learning and teaching in the IT class." [11].

In another section of the project that was used as basis for the model, we initially investigated IT student teachers' previous experience of group work by means of a questionnaire [5]. We also reported on a case study of a group of student teachers, who worked together over the course of one semester's worth of IT modules. An account is given on their preliminary views going into the group work, some of what they experienced during the semester and finally, what they learnt about the assumption of various roles within the group and handling conflict. Analytical discussions of these experiences pointed to ways in which this knowledge can be applied to ultimately support teachers in helping their students to apply group skills effectively in IT classrooms [5].

3. A MODEL FOR GROUP WORK

3.1 Positive Interdependence

According to [3], explicitly structuring positive interdependence in groups is vital for group learning to thrive. The interdependence of group members must be dealt with in such a way that they realize that they cannot achieve success unless all the members of the group achieve success. Mutuality needs to be established in terms of common goals and "benefits from achieving the mutual goals" [8]. Having the completion of the project as a common goal should serve as one of the main factors in uniting group members in a joint effort. This mutual goal should be relevant and convincing enough to overcome students' possible competing agendas and any conflict that might arise within the group. Peer pressure can also play an important role in encouraging good work ethics and commitment to the project.

Benefits received from achieving the common goal (in this case marks for the project) are usually distributed equally among group members, as this highlights the common fate of group members. Results in a study by [7] indicate "that … the majority of the students prefer that a small portion of the (marks) be allocated based on individual contributions, while the majority … is divided equally among the team members."

3.2 Individual Accountability

[18] stress the importance of assessing for individual accountability, to ensure that all group members participate. Individual accountability is important for group success, since some members tend to dominate and some to withdraw, unless mechanisms are in place forcing everyone to participate. Individual accountability is established when each group member understands that she/he is required at each cyclic meeting to briefly report on "what he or she has been working on and what progress has been made." [9]. In this way, the meetings also motivate students to make meaningful progress, so that they have something significant to report. By requiring groups to keep a record of their decisions at meetings, each group member can be held accountable for those parts of the project that the group had agreed was her/his responsibility.

All group members are individually responsible to display their own knowledge and skills with regard to programming by applying these to their parts of the project [13]. Individual accountability is further implemented in the structure of the model in that students also write their class tests and

examinations with regard to their programming knowledge and skills individually [12].

3.3 Interpersonal and Social Skills

It is necessary to ensure "that students are trained in the social skills required to promote group interaction" [3]. Students need to be taught how to communicate with each other [10], incorporating the concepts of compromise, participation, interaction and working together well. It is also important to teach group members how to "avoid negative comments, and to present their critiques in a positive light" [14].

During the first period allocated to the project, students are provided with "training in small group processes and effective member roles in order to maximize a group's success" [12]. This is accomplished by having students participate in various activities and games, one of which "illustrates the elements of proper team organization, namely a clear purpose, a plan, clear roles and (creating appropriate) ground rules." [2].

The actual 'planning meeting' takes place in the second period allocated to the project. During the planning meeting, students are responsible themselves for "creating appropriate ground rules" through discussion within the group [12]. These ground rules govern students' behavior in the group [3], and are reported on as part of group processing.

Teachers also "need to make sure that the time allocated for" planning the group work (at least one period) is spent in appropriate discussion and thorough planning, as this planning 'is important in order for everyone to know exactly what they will be doing." [5]. Each group should provide an "account of how they had planned their work," with details written down of things such as the division of tasks between various members. If careful planning is not put into place, a group might take very long to really get started, and spend "too long changing their minds about what to do, and as a result they might not have … enough time to complete projects as initially planned." (ibid).

3.4 Face-to-Face Interaction

Face-to-face interaction is supposed to take place each time the groups meet, as students sit "in their small groups to carry on their discussions" [13] at their cyclic meetings. These present students with efficient ways to communicate with each another and work together in order to make orderly progress. They need to provide "explanations , elaboration, and guidance to help their peers understand how key principles related to" their responsibilities within the project [13]. A situation needs to be created where students realize that effective learning is a shared responsibility, and where they share their resources, provide mutual support and encourage each other to achieve success [18].

3.5 Group Processing

"(C)ooperative learning tasks" should be "carefully designed and monitored" to ensure that "students engage more actively in their learning experiences." [13]. In order to effectively monitor each group's progress [9], students' mastery and application of group skills are monitored regularly through both observation by the teacher, "as well as through the use of self- and peer assessments (by students) detailed with a rubric", which are "submitted at the end of each" cycle [13]. These assessment reports include items detailing positive contributions from different group members towards the project, possible weak spots displayed, and an indication of the global contribution level for each group member. The reports are then used to provide timely, "more complete and appropriate feedback to students reflective of observations from" their peers and the teacher [9] "about how they are doing as group members" [9].

Those group members who are not always good group workers could at times appear to be bored and don't interact with their groups [5]. Sometimes their efforts and interest are minimal compared to other group members. It could also be difficult to get and/or hold their attention. They might benefit from realizing that it is important for the good functioning of the group to be willing to listen to the other people in the group and find out what their ideas are. This kind of behavior "reminds us that teachers should not only be trained in how to handle 'trouble-makers' in groups, but also how to teach their students how to handle such group members themselves, and any accompanying conflict that might occur because of these 'unruly' learners' behavior." [5].

If the results of group processing show that some students are "persistently disrespectful or uncooperative", it is important that "swift corrective actions be taken to correct (such) situations" [9]. Such students could eventually "be required to work alone or among themselves rather than be an undue burden to other students' team experiences" (ibid). We are convinced that if teachers are well trained in ensuring that these elements are successfully implemented in their students' groups, "a lot of the identified problems would probably decrease." [11]. Building in essential components of effective group work as described earlier should enable groups to work effectively "to bring in the required group projects according to specifications" and initial planning [5]. It is important that the teacher carefully design and monitor the pitch of the project: On the one hand, some of the "tasks should provide a challenge to students", while other tasks "require (the) use of skills that they feel comfortably capable of using to maximize their involvement in the tasks." [13].

A review of research by [3] confirms that the benefits of group learning are enhanced when group size does not exceed four members, as the possibility of free riding increases significantly with additional members added to the group.

3.6 Assigning Specific Roles in the Group

[2] illustrate "that there are several roles necessary for successful team interaction and accomplishment." The main aim of these roles is to assign different responsibilities to group members [11] and determine how group members are to act and/or function with-in the group. In this way 'poor drivers' can be avoided - they usually have "a dominating personality, … (do) not know how to delegate responsibility and (want) to do all of the work on their own." [17]. The opposite would be students who become 'free riders' – they avoid responsibility and/or do not make contributions, but rather are "more than willing to let other students do (all) the work." (ibid).

As the responses in one of our own studies indicated "that most teachers only use a leader when assigning learners in groups" [11], students are exposed to some of the "common pitfalls in leading teams" [2], and how to take up responsibility. Since in-service teachers' responses in that same study indicated that they generally "do not know different roles that can be assigned to (students when) working in groups" [11], this aspect needs specific attention during training workshops.

Students are encouraged to rotate between the different roles what can be assumed within the group, and to record this information as part of their cyclic meeting, e.g. who the leader, scribe etc. was for a specific cycle [9]. The scribe/recorder/secretary is responsible for documenting the group conversation and providing the group consensus solution for the problem [15]. Other positions in a group are "the

speaker/presenter, who presents the group's answer to the class", and "the facilitator, in charge of encouraging everyone to participate" [11]. The role "of a planner, to outline where and how the group is proceeding through the assignment," can be added (ibid).

3.7 Assessing Groups

Results from our own previous research conform to some of those by [18], in that many arguments put forward why teachers do not often use groups when teaching IT centre on perceptions that assessment in group context and the administration of group work is difficult [11]. Teachers need access to techniques that they can implement in order to obtain information for the assessment of individual students in the group project situation. One of the queries most often encountered with regard to the assessment of group work (that teachers need extensive training in) is: "How do we assess the contribution of an individual when the deliverables are a team effort?" [7].

This aspect is intricately tied into the elements of positive interdependence and individual accountability mentioned in previous sections. A final cumulative peer assessment instrument is used that explicitly asks "each student to rate each group member on" group skills such as communication and cooperation [9]. A principle suggested by [14] is used when marking group projects: "All members of a group …start with the same grade, but … that grade (then) needs to be adjusted for each member by some percentage that reflects their individual contribution(s as) measured by (their) peer … assessment(s)."

This model for the use of groups is now implemented and tested in South African IT classes. It is therefore piloted in selected schools in Gauteng to determine the effectiveness of the model when teaching programming, as well as to identify possible shortcomings.

4. PILOTING THE MODEL

We provide a description of the research methodology and data collection and analysis techniques for a pilot case study to exemplify the model.

4.1 Teacher Training

In order to pilot the model, selected teachers are trained in the effective use of group strategies for implementation in the teaching and learning of programming skills in the IT class. This training is in accordance with the model as described in the previous section of this paper, and takes place in a workshop setting.

A pre-test - post-test approach is followed, with teachers involved completing a questionnaire before the training workshop to determine their base knowledge, skills, attitudes and perceptions of group teaching and learning in the IT class. After the training workshop, teachers again complete a questionnaire in order to determine the impact of the training on the same. Due to the small number of participants, mainly descriptive statistical analysis is used.

Workshops are based on a solid theoretical framework for implementing group learning in programming projects, as well as practically applying the knowledge and skills gained. Theoretical and practical aspects are interwoven during the workshop to ascertain that the necessary knowledge, skills and attitudes are acquired in such a way that teachers are able to implement it effectively in their own IT classrooms.

Responses in one of our own previous studies [11] indicated that current IT teachers "lack theoretical knowledge of group work." "Not only were teachers uninformed, but they did not seem to appreciate the dynamics of group work and the contribution that group work could make to effective learning and teaching in the IT class." [11]. Ignorance of the possible advantages of group learning strategies could be one of the important reasons why it is generally not used for teaching programming skills. If such teachers were to undergo training, one needs to query them to establish whether this is in fact the case; if so, they need to be made aware of this potential.

4.2 Teaching the Model in IT Classrooms

The selected teachers then proceed to teach programming skills in accordance with their training in group strategies. During this implementation of the model in their classrooms, we ask teachers to complete a short journal entry for each implementation opportunity, detailing their 'trials and tribulations' of group teaching and learning. These provide rich qualitative information towards the evaluation of the model.

Teachers are visited regularly by the researchers to discuss challenges that they might be facing, with teachers' journals forming the starting point for semi-structured interviews. The researchers "also provide technical assistance and information," as well as "emotional support to help innovators keep up their spirits and their efforts" [16].

Once the pilot study comes to an end in schools, teachers will be asked to complete a final questionnaire. A focus group discussion for teachers is also held as a debriefing meeting to their gain assistance in interpreting the outcomes of the study and "provide a versatile, dynamic source of data directly from participants" [12].

4.3 Future Work

Once the model is piloted, this implementation of the model is evaluated and finalized based on results obtained in the pilot study. A sustainable model is then established for pre-service and in-service teachers, by scheduling training workshops for the broad spectrum of current and future IT teachers. These workshops enable teachers to effectively use group strategies to enhance the teaching and learning of programming skills in their IT classes. Teachers are also empowered to set aside their fears in connection with the implementation of group work.

5. IMPORTANCE OF THE STUDY

As indicated in the introduction, there is a significant body of literature available in IT education, going back a number of years, discussing group work learning and dynamics in programming, software development and computer group projects for university level students. Although the idea of using group learning in IT education is therefore not new [1], given the current widespread use of group learning, it is all the more important that "teachers understand how to structure and monitor meaningful (group) learning experiences for students." [13].

The model explained in this paper uses existing research findings from empirical studies, and re-enforces current thinking by reconstructing what is already reported in literature. The authors' claim to originality in this contribution lies in the log of a large amount of descriptive detail of how this knowledge is applied in the development of this model for the application of group work in the IT classroom, which can also be used in the training of teachers. In this way, the ultimate outcome of the research program makes a significant contribution when results are ultimately relayed back to application in schools to support teachers with help for applying group work effectively in their classrooms.

Further potential of this work is situated in the contribution it makes through the collection, qualitative description and

analysis of teachers' views on their group work experiences in the pilot study. This could contribute as significant work and offer new results and insights that would be of interest to lecturers and teachers across the field of IT education, and thus benefit the SACLA community.

6. CONCLUSION

In light of the scenario as described in the introduction to this paper, students "should be able to work effectively with other members in order to prepare (them) to function effectively in a group context within the work environment." [11]. Empowering students in this way therefore represents a valuable investment in each of these students' futures. We remain convinced that "(i)t is therefore of the utmost importance that teachers be trained in effective handling of group work in the IT class." [11]. This model should enable teachers to understand the dynamics of group work and the contribution that group work could make to effective learning and teaching in the IT class.

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