Project report by Group 5
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How can teachers optimize group learning in Biology?
- a literature review of group projects in higher education

Abstract

Group learning has long been suggested as an effective tool to increase student learning when teaching Biology in higher education (HE). In addition to improving academic knowledge, collaboration has been highlighted as specifically important in Natural Sciences, since cooperation is integral to the field. In this report, we perform a qualitative literature review, aiming to summarize and synthesize current scientific knowledge on group learning in HE and highlight the pedagogical challenges for teachers supervising group work. We focused on group dynamics and the role of the teacher. We conclude that while most studies show positive effects on learning outcomes from group based work, which factors that will determine the success of the project may be highly context dependent, e.g., depending on the length of the project and at which level it is given. In addition, the teacher will need to have a different approach in a seminar setting compared to supervising group projects. In the seminar, the teacher needs to create a framework for the discussion and facilitate it, while in a group project the availability of the supervisor becomes important. The way a teacher intervenes in group work is important, and should preferably be aimed at facilitating group learning rather than just stating facts. The design of group learning should always be adapted to the course and students, rather than using a general approach.

Background

Collaborative learning in higher education and pedagogical challenges

A common method of teaching in higher education (HE), including Biology, is collaborative learning, or group work, which is used to complement traditional lectures (Cooper 1995). The approach is also increasingly becoming a preferred method of teaching instead of individual based tasks (Bertucci et al. 2010). This shift comes with potential challenges to the teacher, since students within study groups can vary in their social dynamics and academic experience. In addition, students may have different affinities for group activities, which can pose a challenge for the teacher to choose methods of teaching that allow all students to come to their right and take an active part. Teachers might also lack the proper skills for supervising group work, and might not take into consideration the students' different academic background and personalities, which ultimately may affect the learning outcomes. Group learning in higher education can take the form of seminars or group projects, where the former is teacher-led whilst the latter is less supervised. This also leads to different pedagogical challenges and potential solutions depending on the context and is not necessarily solved using one kind of teaching technique for the two different types of group work. Taken together, research on how to optimize collaborative learning in different contexts is therefore highly important.

In this report, we will review the current scientific knowledge on the effects of HE collaborative learning. We will focus on teaching within the Natural Sciences in Western curriculum, with emphasis on courses in the field of Biology, teacher-led seminars and small group projects with limited supervision. We aim to identify challenges of group learning based on group dynamics and academic background (e.g., prior knowledge) and discuss potential ways to optimize learning in this context. In this literature review we define 'group dynamics' as interactions between students. We tried to encompass the major scientific findings and theories relevant to the topic of our review.

Overarching theoretical background

In pedagogical literature, the benefits of active student participation are well described, where enhanced learning, increased motivation and participation, critical thinking and exchanges of ideas among group members are some of the benefits identified for students (Johnson and Johnson, 1989, 2009; Springer et al, 1999). Group learning in smaller groups also mirrors the scientific environment where collaboration between scientists is common practice, and may help undergraduate science students prepare for real life work situations (Gaudet et al. 2010). Both Vygotsky (1978, 1986/2000) and Bakhtin (1986) describe the theory behind why arranging students in groups during the learning process is a beneficial way of learning. For example, they argue that the simple act of carrying out a dialog within a group setting enhances learning, since the participants in a cooperative setting listens to the other participants ideas and reflects and integrates them when formulating their own new ideas. Hence, they argue that the meaning and understanding of a subject is a result of interpretations from the process of dialogues. In other words, the learning is augmented through the interactions with others.

Interactions in the didactic process is conceptualized as the didactic triangle, where interactions between content, teacher and student all are connected in the shape of a triangle (Figure 1). For example, this concept has been studied by Kansanen (2003), emphasizing the importance of looking at the entire learning process rather than focusing on one certain aspect. In the context of group learning, the teacher interacts with the content by designing the exercise and creating instructions, the students interact with the content through their project, and teachers and students interact through the supervision provided by the teacher. However, group work also requires interactions among the students themselves, adding another level of complexity. The importance of interactions between learners was brought to attention by Moore (1989). Interactions between students will influence their interactions with the content, which is something teachers must be aware of and adapt their interactions with the students accordingly.

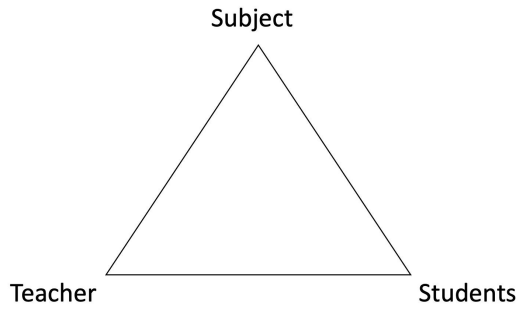

Figure 1. The didactic triangle. A conceptual framework of teaching.

Literature review

Group dynamics, benefits and problems with group learning

Prior knowledge of a subject has repeatedly been identified as one of the most important factors contributing to successful learning and student achievement (Hailikari et al, 2007; Portier & Wagemans, 1995; Thompson & Zamboanga, 2003), especially in science education which often uses applied methods. However, group work as a form of learning may not suit all students. Students may have different educational backgrounds, and hence varying prior knowledge of a subject. This can impede the effectiveness and learning outcomes of group work (Molina et al. 2017; Woolcock 2007), for the group as a whole but also for the individual student. Suggestively, a consequence of this is the so-called "Hitch Hiker Problem", which stipulates that high achieving students may resent group based learning due to lower achieving students "hitching" onto the formers' relatively higher knowledge or skill (Cooper 1995). However, this scenario is perhaps a worry that bothers teachers and instructors unduly (Cooper 1995). In a study by Gaudet and colleagues (2010), upper-level university students were quizzed in a biology class twice, with a group session for a subset of the class in between the quizzes, in order to gauge the effect of group learning (Gaudet et al. 2010). Given this set-up, the improvement of students could be measured individually, and from this, students were identified as "term high achievers" and "daily top performers". While groups rarely reached higher quiz-scores than the local "daily top performer", the "term high achievers" significantly improved their knowledge throughout the course, when compared to an equivalent subset of students not part of the group sessions (Gaudet et al. 2010). This suggests that group learning will have positive effects on high achieving students as well, given a longer time-span (Gaudet et al. 2010). Additionally, one must not forget the documented positive impacts that group work has on the class as a whole, effectively increasing the average learning outcome (Gaudet et al. 2010). Furthermore, learning outcomes other than improved academic knowledge (in this case quiz score), may be achieved through group learning, such as improved collaboration and solidifying knowledge already possessed.

Other studies have looked more broadly at which aspects of group learning will be positively perceived in terms of learning by university level biology students. The work of Scager et al. (2016) encompasses five courses of biology and from group interviews with students identifies factors which were perceived as beneficial in terms of learning. Among these, student autonomy, the perceived relevance and complexity of the topic were highlighted as positive for facilitating group learning (Scager et al. 2016). The authors relate this to self-determination theory (Scager et al. 2016), which states that competence, relatedness and autonomy all are determining factors for motivation (Deci and Ryan 2000).

Additionally, Wheater & Bunleavy (1995) listed both benefits and problems with teaching in the form of group projects in ecology. Three main categories of benefits were listed: academic development, personal and social development, and logistic and practical reasons. According to Wheater & Bunleavy (1995), academic development is enhanced since students are allowed to take active part in the learning process and since they get the chance to learn from each other, while social development is strengthened through the introduction of collaboration. However, Wheater & Bunleavy (1995) also stressed that students can not be left without supervision during group work. They identified potential problems regarding group selection, group management, the role of the teacher, and the assessment. The authors addressed that group composition can determine the success of a project, where there may be problems with low motivation, conflicts and parasitism in dysfunctional groups. Regarding group management, they pointed at the need for division of tasks, coupled with the risk that someone becomes dominating or hides behind a simple task to avoid work.

However, it is worth noting that what part of their education the students are in may influence how group learning is best optimized. The work of Scager et al. (2016) focuses on middle and upper-level courses; the authors note that a homogenous level of motivation is mentioned as improving group dynamics, in addition to students having worked together with each other before (Scager et al. 2016). First year courses may therefore face other challenges in terms of group dynamics. One example of this could be so called “dominators” who, by taking up a disproportionate amount of time in discussions, negatively affect the learning outcomes of the group (Theobald et al. 2017). In their study of an introductory level biology course, Theobald and colleagues were able to show that the negative effect caused by dominators could be mitigated by increasing the structure of the task (Theobald et al. 2017). For example, Theobald and colleagues used a so-called “jig-saw” approach, where students work independently, then in small groups, on separate parts of a larger problem in order to foster positive interdependence.

A teacher's perspective on group learning - seminars

According to Tutarel et al. (2000), an appropriately designed learning seminar should begin with a concise introduction by the teacher. This should be followed by an engaging exercise which promotes interaction between the students. Furthermore, the task should be based on skills that the students previously have possessed, but be designed to allow the students to further analyze and advance this knowledge. Additionally, Tutarel et al. (2000) argues that the seminar should be as similar as possible to a real life professional situation.

The teacher has a dual role in a seminar, as both an expert on the subject and as a facilitator who should manage the group in a way that allows the students to reason with each other (Spruijt et al. 2014; Dolmans et al. 2002). Aarino et al. (2014) studied the nature of teacher interventions during problem-based learning. They found that teachers most commonly intervened by giving factual explanations or confirmations of what the students themselves had stated. More rarely, the teachers asked questions aimed at elevating the discussion. Aarino et al. (2014) also found that teachers were more likely to intervene in matters revolving around facts rather than broader concepts. Assen et al. (2016) found a similar pattern, specifying that interventions were primarily teacher-oriented (focusing on passing on knowledge) rather than learner-oriented (assisting in the learning-process). Both Aarino et al. (2014) and Assen et al. (2016) argue that teachers need to be trained in the field of facilitating learning.

The importance of the group-dynamic skills of the teacher was emphasized by Dolmans et al. (2001). In a study on the role of the teacher in a seminar setting, Jaarsma et al. (2008) found a strong connection between the achievements of the teacher and the learning result. Inadequate management of group dynamics was seen to have a negative effect on the learning outcome. Lee et al. (2013) studied how group dynamics were facilitated by experienced teachers and concluded that it was important to delegate responsibility to the students, ensure a good learning atmosphere and allow the discussion to flow. Doherty et al. (2018) found that teachers spending more time to prepare also were better at managing group exercises.

A teacher's perspective on group learning - project work

Johnson et al (2013) describes five basic elements of cooperative learning that teachers should implement during class in order to facilitate active learning during smaller group work. To briefly summarize the five elements: the first element focuses on positive interdependence, that is, one student can not succeed if the group as a whole does not succeed; the second element focuses on face-to-face dialogues that will encourage e.g., sharing of ideas and knowledge or how to solve problems; the third element focuses on individual accountability which may help counteract so called “hitch-hikers”; the fourth elements focuses on the students social skills (perhaps something that has to be taught separately) that is necessary for the group dynamics, and finally; the fifth elements focuses on group processing, reflecting over how the whole group work assignment went and what could have been done differently. Additionally, Wheater & Bunleavy (1995) emphasized the necessity of teacher guidance to ensure that group projects run smoothly, and the importance of availability of the supervisor over the course of the project, preferably with regular progress meetings. The authors suggested that increasing autonomy can be given to students working on group projects over the course of a programme.

Conclusions

Implementing group work, both as seminars and project work, as a teaching method is beneficial for students learning in HE (Cooper 1995). By working in groups, the students can experience enhanced learning by being able to express and discuss their ideas and feel more

motivated to perform the task at hand in a collaborative setting compared to working individually.

However**,** while there are several factors which may impact the learning outcome of collaborative learning, such as group size, motivation, homogeneity and diversity, certain aspects may carry larger implications depending on the setting. The worry of high achieving students not benefitting from group settings in terms of knowledge gain (the hitch hiker problem), appear to be applicable to shorter time-spans, such as a single discussion, but not be a significant issue long-term (Gaudet et al. 2010). Similarly, other effects of group dynamics can also be context dependent, e.g., the level of autonomy a group is given, which has been shown to improve motivation (Deci 2000; Scager et al. 2016). Such independence relies on a group being somewhat homogeneous in terms of motivation and having a functioning social dynamic, since individual group members can negatively impact the learning outcomes by dominating the session (Theobald et al. 2017). A suggested solution to handle such problems is to increase the structure of the task (Theobald et al. 2017), thus effectively limiting the freedom of the group. This suggests there are certain interactions between factors determining the learning outcomes in group settings, both in terms of the length of the project but also in terms of the prerequisites for the class itself. If students are in their first year and therefore do not know each other, in addition to having varying levels of knowledge and motivation, high levels of autonomy may have a generally negative impact on student learning. The opposite is however likely true in courses at a higher level where instead too much structure will be a hindrance. Consideration should also be taken to the length of projects as single or short-term projects may not benefit high achieving students, while longer or more frequent will. Taken together, understanding the context of a group project is highly important in terms of how to optimize it and such factors should be taken account for, not the least, whilst interpreting current scientific knowledge on collaborative learning.

Group projects and seminars are two situations with group work that pose considerable differences when it comes to the role of the teacher. In both cases, challenges for the students with regards to group dynamics are fairly similar. For the teacher however, the conditions are different. As is argued by Tutarel et al. (2000), a successful seminar requires that the teacher sets a clear framework within which the students can operate. At the seminar, the teacher can actively influence the discussion through the nature of their interventions, in accordance with the studies of Aarino et al. (2014) and Assen et al. (2016). In group projects, the students are given a higher degree of freedom and the teacher has less of an overview than in the seminar. An easy pitfall for the teacher is to leave the students to their own and only act if necessary. However, as Wheater & Bunleavy (1995) points out, the teacher needs to be available to ensure the best outcome for a group project, preferably with pre-planned meetings.
It is understandable if untrained teachers believe that the outcome of interactive learning amongst students comes down to the students themselves and their interactions. This is part of the picture, but from the literature review it is evident that the teacher plays an important role as well. The social skills of the teacher are as important as the mastery of the subject, and

is something the teachers often are not trained in. We argue that raising awareness of this among seminar teachers is a good first step, preferably combined with formal education in pedagogics where these issues are addressed. Other than that, we consider the framework for a seminar session proposed by Tutarel et al. (2000) to be a good basis for a successful seminar and the principles listed by Wheater & Bunleavy (1995) to be useful in group projects. In both cases, the active participation of the teacher in the learning process is important. In summary, teacher awareness of the context dependent challenges of group learning is highly important and instead of us giving step by step instructions on how to supervise group work, we emphasise that teachers should be aware of the challenges and adapt their approach accordingly.

Overall, our main findings regarding the role of the teacher can be summarized as follows:

- At a seminar, the teacher should provide a clear framework within which the discussion can take place.
- The nature of teacher interventions in a discussion is of relevance, where it is as important to facilitate further discussion as it is to give factual answers.
- During group projects, it is important that the supervisor is available, preferably with regular planned progress meetings.
- The importance of structuring group work is greater in undergraduate courses, and larger autonomy can be given later in the programme.
- One important step to improve group work is to increase teacher awareness about the dynamics between students that they may need to handle.

Process report

For the literature review, we followed the time plan presented in our project plan, which consisted of both independent reading and writing, and regular group meetings face-to-face to discuss the progress of the literature review. Firstly, we all read about the theoretical theories and we then assigned different parts for each of the group members to read and write about.

We all read and understood each other's assigned parts and all group members contributed to the final structuring and writing of the literature review.
All group members agree that this way of dividing the different parts worked well overall. This allowed each group member to focus more on a specific topic. This was important since we are not familiar with the literature covering pedagogics. This way, we could summarize the content for each other. However, the initial draft required further revision to make the end-result more coherent.

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Feedback summary

The feedback we received on our group report at the feed-back meeting addressed how the title was formulated, that we did not mention the result obtained from the literature review in the abstract, that we should emphasise that this is a literature review based on Western education curriculums, that we did not present how we defined 'group' dynamics' in this literature review, how we decided which articles to include in the literature review, that a figure of the didactic triangle would clarify the interactions within group work between the students, teachers and subject, to give an example of how the so called 'dominant' students during seminars could be addressed by the teacher, that we seemed to focus on the so called 'high achievers' during group work and did not discuss the 'other' students within group work and that we did not have some type of summary of the main results of how teachers can optimize group learning.

The feed-back we received from group 4 was thoroughly thought through and we decided to address the following issues. The title of our literature review, "How can teachers optimize group learning? a literature review of group projects in higher education in Biology" could be interpreted as misleading since the articles included in the literature review was not solely within the field of Biology, instead we included articles within the Natural Sciences. We therefore changed the title to "How can teachers optimize group learning in Biology? a literature review of group projects in higher education". We agreed that a sentence about the main results from the literature review should of course be added to the abstract, which we did. We also added a sentence stating that this literature review is from a Western educational view, that in this literature review we define 'group dynamics' as interactions between students and that the articles included in the literature review were chosen in an attempt to encompass the major scientific findings and theories relevant to the topic of our review. We totally agree with group 4 that by adding a figure of the didactic triangle to the literature review, it clarifies how group learning fits into the theory about the didactic process. In addition, we agree that we should have given an example of how the so-called 'dominant' students during seminars could be addressed by the teacher leading the seminar, since we to emphasise how teachers can optimize group learning for everyone, which we did. We got some criticism about just presenting the perspective of the so-called 'hitch-hiker' students and that we did not discuss the 'other' students within a group. We have now expanded this paragraph to include more aspects of the multitude of positive impacts from group learning and its general effect on the entire student population. While we agree that other perspectives could be included on e.g., how other subsets of a student group (gender, ethnicity etc.) may be impacted differently, we believe that this is out of the scope of the current topic, given the page limit of the report.

In addition to expanding and defining parts of the text above, we have performed minor text edits throughout. We are thankful for the feedback of group 4, which has allowed us to improve our report further.