

Team-Based Learning in Honors Science Education: The Benefit of Complex Writing Assignments

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INTRODUCTION

Cooperative learning and team-based learning have been widely recognized as beneficial strategies to improve all levels of education, including higher education. The benefits have been widely researched and are now well-established (Johnson et al.; Michaelsen, Bauman Knight, et al.; Michaelsen & Sweet; Slavin; Springer et al.). The studies have indicated a positive relationship between cooperative learning and student effort, achievement, persistence, and motivation. Just forming groups, however, does not automatically lead to better learning and motivation; cooperation flourishes only under appropriate conditions (Fink; Gillies; Parmelee et al.). This potential for cooperation and learning is maximal when groups are structured in such a way that students understand what is expected of them and how they are supposed to work together (Johnson, Johnson, & Smith; Michaelsen & Sweet).

High-ability students learn differently than their peers; they are quicker in their thinking, more flexible in their strategies, and better at memorization; they know more and prefer complexity (Freeman; Shore & Kanevsky; Wallace). Furthermore, high-ability students need less structure (Snow & Swanson). Finally, when motivation is an important selection criterion for honors students, as it is in Dutch programs, these high-ability students are more motivated than their peers. Given these differences, high-ability students require different instructional conditions to benefit optimally from assignments based on cooperative learning.

We can provide two examples of student-driven honors courses in which students work in teams on complex assignments. These courses, which are designed based on characteristics of cooperative and team-based learning,

have revealed that team-based learning works best for honors students when (1) courses are student-centered rather than teacher-driven, (2) the teacher's role is to coach and facilitate, and (3) the assignments are complex and challenging.

SOME CHARACTERISTICS OF COOPERATIVE LEARNING AND TEAM-BASED LEARNING

Fink distinguishes between three general uses of small groups in higher education: casual interaction, cooperative (or collaborative) learning (CL), and team-based learning (TBL). An example of casual groups is the “think-pair-share” strategy, where short interactions between students are designed to enrich large-group lectures. After the teacher asks a question, the students discuss possible answers with their neighbors, sharing some of the answers before the teacher continues lecturing.

The distinction between CL and TBL is mainly the level of interaction and interdependency, which is more intense in teams. A team is more cohesive than a group because the students spend a long period of time working together and/or have a higher level of accountability and shared responsibility. Teams have two major advantages over groups in an educational setting: individual team members learn to commit a high level of effort to a project, and learning teams can solve problems beyond the capability of even their most talented members (Fink; Michaelsen, Watson, et al.; Michaelsen, Bauman Knight, et al.). Michaelsen and Sweet describe four essential elements of TBL that transform newly formed student groups into high-performance and cohesive learning teams:

- **Groups** need to be properly formed and managed.
- Students must be **accountable** for the quality of their individual work as well as their group work.
- Students must receive frequent and timely **feedback**.
- **Design of group assignments** must promote both learning and team development

In TBL, small groups are a semester-long instructional strategy in which a sequence of activities is designed and linked so that they accomplish deepening of student learning as well as enhancing the development of team cohesion (Fink; Michaelsen & Sweet). In contrast, CL is often focused on assignments that can be finished in days or weeks, generally too little time to allow formation of cohesive teams.

The two science honors courses we designed at Utrecht University implement TBL in complex, semester-long assignments in which students

write PhD proposals or a year-long project of writing a popular science book. We also introduced such features as student-driven course design, student leadership roles, teacher-as-facilitator roles, and complex writing assignments. Students in both courses are motivated and eager to create products that surpass the products produced by previous groups, which, according to their teachers, they regularly do.

ASSIGNMENTS AND STUDENT ACTIVITIES IN SCIENCE HONORS COURSES

WRITING A RESEARCH PROPOSAL IN THE ADVANCED MOLECULAR CELL BIOLOGY COURSE AT UNIVERSITY COLLEGE UTRECHT, THE HONORS COLLEGE OF UTRECHT UNIVERSITY

In this course, three small teams of four or five students cooperate intensively during a semester of fifteen weeks to formulate three PhD proposals within an overarching theme. Since the course is student-led, all decisions are made by the students with instructors playing a facilitating role by asking critical questions and providing feedback throughout the course. The instructors refrain from guiding the students in their decisions about the various elements of their research proposals.

This course is designed to have a number of phases and aims (Wiegant et al.). First, students become familiar with background research by not just reading but also presenting and discussing primary papers in the field of their proposals. Next, students identify a gap in knowledge and formulate research questions aimed at getting beyond what is currently known. The third phase, typically the most challenging, is identifying a set of techniques that are most appropriate to answering the research questions; in this phase, students contact experts and visit laboratories to grasp the state-of-the-art advanced research technologies in the field of molecular and cellular biology. Finally, students formulate a research program and design PhD projects that they will present and defend before a jury of experts.

During this fifteen-week course, the student teams cooperate intensively to achieve their goals, producing numerous presentations and discussions on ideas and on the progress of their research projects. A program leader, together with project leaders, is responsible for making the program coherent and preventing overlap between projects. Critical readers provide peer feedback on each other's projects, and a layout team is responsible for printing the research program plus proposals. An important factor in achieving cooperative learning and team coherence is the requirement that all students be

accountable for the content of the project and be able to answer critical questions at every stage of their project. Examples of research proposals written in the Advanced Cell Biology course appear at: <http://www.uu.nl/university/college/EN/studying/advancedcellbiology>.

WRITING A POPULAR SCIENCE BOOK IN THE HONORS PROGRAM OF THE DEPARTMENT OF BIOLOGY, UTRECHT UNIVERSITY

This honors program is offered in addition to the regular biology curriculum and has been developed for fifteen to twenty motivated and talented biology students. An important element of the program is a group assignment in which students perform all the activities necessary to write, edit, and produce a book: selecting a theme and chapter topics, writing the chapters, seeking expert feedback, receiving and providing peer feedback, editing chapters, designing layout, making illustrations, and presenting the product at a self-organized symposium.

Students read primary articles on their topic of choice, invite guest speakers on relevant themes, and contact experts for interviews as well as for feedback on drafts of chapters they write. The student editorial board composes a time-table to which all need to adhere, solves problems, and enforces deadlines. Students assign themselves the tasks that are required to finish the project in time.

In 2010, the biology honor students wrote and published a book on biological topics that they considered important to the twenty-first century (ISBN 978-90-77024-60-7). In 2011, the theme of the book was “Synthetic Eden” <http://urandom.nl/synthetic/bundle.html> and focused on various aspects of biotechnology. In 2012, the students wrote the book *Life Support*, which was inspired by topics in the field of sustainability (ISBN 978-90-77024-65-2).

SUPPORTING TBL IN HONORS EDUCATION

STUDENT-LED COURSE DESIGN AND STUDENT ACCOUNTABILITY

An important element in our honors education is to provide less structure and guidance than is usually offered in regular courses and at the same time to express high expectations for what students have to achieve. In our student-driven environment, students themselves are challenged to create the environment in which they can perform optimally.

The students know from the outset that they are accountable not only for their own team project but also for the coherence of all the projects within the

overarching topic. Students thus must communicate well within their team as well as with other teams and must support other teams when needed. This positive interdependence, which is the main precondition for effective cooperative learning (Johnson & Johnson), is a natural byproduct of the courses' complex writing assignments. Students develop cohesive teamwork when they know that they are individually and collectively accountable for an actual product like a PhD proposal or a book, and they develop a sense of shared ownership that further supports team spirit.

The advisability of assigning roles to increase accountability is controversial in the literature on CL and TBL (Michaelsen, Bauman-Knight, et al.). In CL, teachers usually assign specific rotating roles to allow all students to experience each role, learn the required skills, and contribute equitably to the group process. In TBL, assigning roles is generally unnecessary and sometimes even counterproductive (Fink). In our honors courses, we encourage students to assign themselves specific tasks that are required to achieve a successful product at the end of the course, i.e., being a program leader, project leader, or critical reader in the PhD proposal course. The main aim of having students assign their roles in honors courses is twofold: to develop leadership skills and to allow them to structure the course in such a way that obtaining content knowledge as well as the creative process of writing a complex assignment is most optimally organized. In this way, the students develop a sense of ownership and independence while also facilitating the teacher's communication with the student teams.

THE TEACHER AS COACH AND FACILITATOR IN HONORS COURSES USING TBL

The role of the teacher in CL and TBL is described as facilitative, a term that includes structuring the process, determining the learning objectives, deciding on the cooperative structure, monitoring progress, and assessing students' learning (Johnson & Johnson; Michaelsen, Bauman Knight, et al.; Parmelee et al.). Since students in TBL are more actively engaged in the learning process, teachers often report being more relaxed and experiencing more joy (Michaelsen, Bauman-Knight, et al.; Bauman-Knight). In TBL, the teacher is supposed to provide guidance in the form of well-planned and well-structured activities together with prompt feedback, an important feature to improve student learning. In our honors courses, however, such guidance has been reduced to a minimum so that students can develop activities and initiatives they consider most relevant to their goal; the teacher's role is thus to ask critical questions, to facilitate, and to coach in order to encourage the students to excel and to go beyond their comfort zones.

In a student-centered honors course, emphasizing what the teacher should *not* do is also important. We encourage student-led decisions in shaping the course and thereby their final product, thus enhancing their sense of ownership and their pride in what they have achieved, so teachers should keep some distance from the students' decision-making process. Teachers ask critical questions on ideas and hypotheses that students suggest, and they provide feedback on drafts of texts but refrain from offering their ideas of best solutions or strategies. Even though students expect more direction from their teachers, they have reported learning much more by feeling lost at times but managing to find solutions themselves (Wiegant et al.; Scager et al. [2012 and *in press*]).

CHALLENGING HONORS STUDENTS WITH COMPLEX WRITING ASSIGNMENTS

Honors students need a higher level of complexity to challenge them (Kanevsky and Keighly). Writing assignments such as a PhD research proposal or a popular science book are exceptionally complex for undergraduates. Writing a research proposal, for instance, requires that they read primary texts, find gaps in knowledge where research can go beyond what is currently known, find the best techniques and research strategies to fill the gaps, write a coherent PhD proposal, and defending the proposal in front of a jury of experts. Many of these activities require higher-order cognitive skills including analysis, synthesis, and evaluation (Bloom; Wood). Practicing these skills also supports the development of critical and creative thinking, two of the academic competencies encouraged in honors education.

WHAT IF STUDENTS ARE (OVER)CHALLENGED?

According to Csikszentmihalyi, learning takes place most efficiently when the challenge of assignments is in balance with the skills students have developed. During some phases of our Advanced Cell Biology course, students reported that the challenge was much greater than their skills. Although they reported that this imbalance affected their motivation in a negative way, they nevertheless indicated that they extended their efforts and learned a lot (Scager et al. [2012]), and they were able to come up with high-quality projects that impressed the jury of experts. At the end of the course, students were interviewed using the so-called story-line method (Beijaard et al.); we asked the students to identify the elements of the course that they experienced as challenging in order to analyze how the high level of challenge as well as working in teams affected their learning outcomes.

STUDENT EXPERIENCE

In the first two phases of the course focused on writing a PhD proposal, students experienced a balance between challenge and skills. However, in the third phase, when they needed to identify appropriate techniques, the challenge was much greater than what they thought they could handle. They often felt frustrated and, when looking back, said they missed having guidance from the instructors. Nevertheless, students reported that they continued to learn a lot, that the lack of guidance stimulated their learning, and that finally they were able to produce an excellent and coherent research program that included three PhD proposals. The jury members were without exception impressed by the high quality of what the students produced as well as the mastery of the subject matter they demonstrated during the defense (for more details, see Wiegant et al.). Students also indicated that the group work was mainly what had enabled them cope with all the challenges; they helped each other out of pitfalls and achieved a product they were proud of.

The factors that students have experienced as most challenging in this course include the following:

- The complexities of the task, including the novelty of working with primary research articles, the specialized field of knowledge in cell biology, the dynamics of the process in which a large number of decisions needed to be made, and the conflicting demands of writing a research project that was novel, relevant, and feasible;
- The lack of guidance by the instructors, which was sometimes experienced as too challenging but which students eventually recognized as the best way to learn during the process; and
- The high expectations of the teachers combined with the students' desire to outdo the groups of previous years (Scager et al.[2012 and *in press*]).

We deduce from these reactions the following conclusions:

- Students learn most during the phases when they are over-challenged;
- Temporary frustration does not appear to be detrimental; and
- Less guidance is beneficial for learning.

Team-based learning is probably the explanation for the fact that honors students performed exceptionally well even in situations where challenges and skills were not in balance.

CONCLUSION

Our experience with team-based learning leads us to recommend it as an effective and appropriate strategy for teaching honors students. Complex and challenging assignments in the context of TBL enable undergraduates to

stretch their skill, confidence, and motivation to perform better than they imagined they could. The frustrations they inevitably feel in facing assignments that seem beyond their reach are mitigated by the support of their groups, and, by turning to each other rather than to the teacher for guidance, they experience the world of research as it is experienced by graduate students and professionals in the field, giving them and also their teachers a high level of pride and satisfaction.

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