

From the International Desk

From Problem-Based Learning to Undergraduate Research: The Experience of Maastricht University in the Netherlands

In the current knowledge economy, information quickly becomes obsolete as new knowledge becomes available based on technological developments. Therefore it is important to educate young people to look at existing knowledge critically and then to teach them how to generate new knowledge. Due to limited resources, packed curricula, and limited involvement of researchers in bachelor's degree programs, this is easier said than done.

The Boyer Commission (1998) called for more attention to the integration of education and research. In the Netherlands the need for more research embedded in academic bachelor and master's programs has also been recognized (Commission Veerman 2010). This can produce a more challenging learning environment for ambitious and motivated students and can help university staff identify potentially talented young researchers. One of the educational formats with a clear research component is problem-based learning (PBL) (Spronken-Smith et al. 2008; Levy 2011). PBL has been the core of education at Maastricht University (UM) since it was founded in 1976, and in fact UM is the first university in the Netherlands that applies this effective and successful system in all its programs.

Problem-based learning has several specific characteristics. First, it is student centered, which means that students are personally responsible for their academic education. Second, students work in small tutorial groups, conduct discussions, exchange knowledge, and formulate their own learning goals as a group. This motivates them to do research themselves. Third, tutors guide the group process, ask critical, substantive questions, share their knowledge, and support students when needed. In this way, students get the maximum benefit of tutors' expertise. Fourth, students' learning is supported by learning and resource centers that offer an extensive selection of study materials tailored to the subject matter currently being examined by students. Although PBL has a clear research component, its transformation into undergraduate research (UGR) requires some adjustments, several aspects of which we discuss in this article.

The Road to Undergraduate Research

As we've noted, problem-based learning is at the core of the educational format of Maastricht University. This approach was introduced because of the need for a new kind of graduate, one able to work across disciplines, work in teams,

exercise self-discipline, and undertake lifelong learning. In the PBL system, students work in small groups (10 to 13 students) on actual or simulated problems under the supervision of a staff member. The problems involve short descriptions or compilation of phenomena and events that have relevance to the real world. In Box 1 an example of a problem is given. These problems, however, are not presented by a client (there's no real ownership of the problem) nor is there an actual presentation of the solutions/suggestions to the client.

The problem has to be analyzed, explained, and/or solved by the tutorial group in terms of underlying principles, mechanisms, and processes (Moust, Bouhuijs and Schmidt 1989; Van Berkel et al. 2010).

Box 1. Example of a Problem in Problem Based Learning

CONTEXT: This is a problem used in the course International Business Strategy. In this course the management team of an international company producing furniture is monitored during the internationalization process.

Problem 10: Working together by companies

The new expansion ideas of the management team will put the company under a lot of stress. The future becomes more complex, dynamic and uncertain. Another consequence is that the company will need more raw materials. Mr. Svennson (production and purchasing) suggests that "the company should have closer relations with suppliers. In this way, the company could have more control over the supply of wood. Furthermore, more suppliers are needed, and regarding the production capacity, I conclude that the current capacity is insufficient. Collaboration with others is a solution."

Also Mrs. Fältskog (Director) is looking for ways to collaborate with other parties. "Maybe we can join a warehouse with another company. " Mr. Ulvaeus (Research and Development) comments: "We should not collaborate in production, because this would mean that we give away the advanced production technology of the company."

The problems are processed during two sessions. In the first session, prior knowledge is activated by brainstorming about possible problem statements. As a conclusion, the learning goals are formulated. After this session, students study literature on their own with the aim of meeting the learning goals. Ideally, no specific chapters of reading are assigned, and students are required to find literature by themselves. In the second session, students report on their responses to the learning problems and check that the learning goals have been met. If necessary, new learning goals are formulated. With respect to the problem presented in Box 1 students had to read two book chapters on collaboration in an international environment. The supervisor monitors the process and provides feedback on the learning process, but the students themselves are responsible for their own learning process, for formulating their own learning goals, and for chairing the sessions.

By using PBL, students develop research skills in formulating research questions, selecting relevant sources, analyzing literature, comparing different sources of information, and applying literature to situations. Furthermore, they develop social skills and a positive attitude to lifelong learning. In addition to the discussion of problems, there is room to discuss papers, presentations, or case analyses. Although PBL may look like a standardized procedure, there is a broad range of designs for its implementation. However, the starting point of the learning process is always the introduction of a problem to the students.

To further encourage talented and motivated students to critically evaluate existing knowledge and create new knowledge, the government established the Sirius program, which offers many extra activities for such students (see Box 2).

Spronken-Smith (2008) has classified PBL as a subset of inquiry-based learning, and states that the focus on research could be even stronger if more attention were paid to both the knowledge gap in a discipline, rather than what students don't know, and the production of new knowledge, rather than the transfer of existing knowledge to students. For example, using problems of existing companies can improve the social relevance of research, as well as train students to develop research skills, apply new knowledge, and present their findings to a different kind of audience. As a consequence, most projects in the Sirius program will be custom-made for the students and require another educational format. Several hurdles must be overcome, however. First, because the PBL system requires the students to work in teams with the same learning speed and similar learning paths, it is difficult to have a custom-made learning path for the more talented student. Another hurdle is the Dutch culture of egalitarianism, in which it is difficult to create something special for people who are already talented.

Box 2: The Sirius Program Promoting Excellence in Dutch Higher Education

Talented students need to be challenged and encouraged to do their very best. This is being recognized more and more in the Netherlands. In addition to the importance for the students themselves, it is also particularly important to society at large because today's students are the future. Our country will benefit if these talented people are challenged at an early stage to reach for even greater heights.

Traditionally, the Netherlands has a culture of egalitarianism in education. Various inspections and accreditation authorities guarantee that all educational institutions offer a good basic level, accessible to all students. Nonetheless, a relatively large number of students do not feel sufficiently inspired or challenged. A culture of inclusion prevails: While attempts are made to help less talented students keep pace with the basic curriculum, the facilities to encourage high-potential students to achieve excellence are insufficient. ...

The largest portion of the Sirius budget has been earmarked for the Bachelor's program that was launched in 2008 (48.8 million Euro). ... These funds provide the first incentive aiming at inspiring the top 5% of the students to achieve excellence.

(<http://www.siriusprogramma.nl>)

Based on a request for grant proposals by the Sirius program, a group of enthusiastic educators and researchers at Maastricht University wrote a proposal seeking a grant to extend the current PBL system to undergraduate research. Two main differences in the research orientation are the amount of time actually spent on just one research question and the fact that the undergraduate research students are working on authentic problems, presented by actual clients or as a part of a large research project at the university. The framework developed by Willison and O'Regan (2007), which described research skills, was one of the leading elements in the successful proposal for a grant to establish the Maastricht Research Based Learning program.

The program has three key elements. First, in small groups supervised by renowned researchers, students work on fundamental or applied research over a longer period of time, five months instead of eight weeks. The students learn to think independently and to cooperate with researchers. A small scale is essential, because only then can subtle learn-

ing and interaction with university researchers (in a traditional master-apprentice relationship) take shape. With this approach, the development of more critical and analytical thinking and scholarly work is actively encouraged. Second, it is preferable that this work take place in a setting in which students learn together with students and staff from other disciplines. Third, socially relevant partners or businesses also contribute research questions.

Implementation

This research-based learning program is coordinated by a steering board (with a project manager directly under the supervision of the vice chancellor of the university) and board members from the different faculties, who coordinate the actual implementation of the research projects at the faculties. The steering board is responsible for monitoring the quality of the research projects, communication about the program, the financial compensation for faculty members tutoring the students in their research project, and the development of tools for evaluation. To monitor the quality of the research projects—the academic level of the tasks conducted by students and the skills learned—a set of 10 criteria have been developed. A few of these criteria are presented in Box 3. The research projects conducted by the students last for at least three months in the final year of their bachelor's degree program, mostly combined with their bachelor's thesis. Students obtain 17 or 18 European Credits (ECTS), for their research project, roughly the equivalent of credit for three regular courses. Thus the undergraduate research is part of the curriculum, rather than being extracurricular or summer research, as is often the case in the United States.

Students meeting certain academic and progress standards can submit a research proposal or letter of interest. Based on these, students are invited for a short interview with a faculty member and then accepted or rejected. Exceptions are made for students who don't meet the criteria for the program, based on an assessment from a student's tutor. Our experience has been that motivation is far more important for a successful completion of the research project than grades.

All faculties at MU have produced detailed project proposals that have been accepted and implemented for this research-based program. An example of such a research proposal is presented in Box 4.

Courses on research and the availability of space for innovation in the educational program differ by faculty, so the formats of undergraduate research also differ. Although the formats differ, they have two aspects in common—students write a research paper and the research done by students helps to develop new knowledge or ideas. In their research paper, students have to write a section on the theoretical

Box 3. Examples of Criteria for Assessing the Quality of Research Projects

1. Description of the research. The research must be authentic research, under the supervision of renowned researchers at Maastricht University (e.g. a real research question presented by an external client or as a part of a large research project at the university).
2. Description of the didactical concept on research in the project. What research skills do the students learn? How?
3. Description of the organization of feedback in the research projects. How often is there interaction between the students? How often is there interaction between the researcher and the students?
4. Description of the assessment of the students.

Box 4. Example of a Sirius Research Project at Maastricht University

At the School of Business and Economics, research is done in collaboration between companies. This builds on the problem as presented in Box 1. Students can participate in this research by focusing on one of the research questions.

Companies that pursue an internationalization strategy have different ways to collaborate with other companies, e.g., mergers, acquisitions, strategic alliances, and joint ventures. When companies internationalize, they are confronted with new legal systems, cultures, organizational structures, and management teams. Based on this observation, the following research questions can be formulated:

1. How do organizational structures influence the success of collaboration between companies?
2. How does the national legal system influence the kind of collaboration between companies?
3. How do cultural differences between countries influence the success of collaboration?
4. How do personalities of managers influence the success of collaboration?

background, describe the research method, analyze the results and discuss the findings. (A series of these research papers will be published quarterly.)

Three kinds of models emerged that fit the model of Healey and Jenkins (2009) (see Figure 1). First, in the model used by the faculties of psychology and neuroscience (M1), students conduct their own research under the guidance of a staff member. Individual coaching is combined with group meetings in which students learn to reflect on draft products and the results of fellow students. The group meetings can also be used for lectures on specific research themes. Both the School of Business and Economics and the Faculty of Law use a second model (M2) in which the faculty members determine which courses should be organized around a research-based track. Subsequently, students are selected for the track and attend extra lectures on specific research skills alongside their regular sessions within the courses. These extra classes are combined with the analysis of research articles. Again, students conduct individual research in line with the subject of the courses. In the third model (M3), used by the Faculty of Arts and Social Sciences and at the University College Maastricht, students can apply for a separate research-based course organized around a specific theme. Students define their own research question within the central theme and develop their research methodology. Lectures in this model are based on research skills, combined with the analysis of research articles. Compared to the second model, in the third model students play a more active

role in discussing both content and process. In the second model, staff members are more active because the research projects are part of regular courses.

Figure 1 illustrates the diversity of research projects developed at Maastricht University. This is in line with the observation of Healey and Jenkins (2009) that a variety of methods of learning is appropriate to respond to the variety of learning styles of students and to the various research disciplines at a university.

Experiences with Research-Based Learning

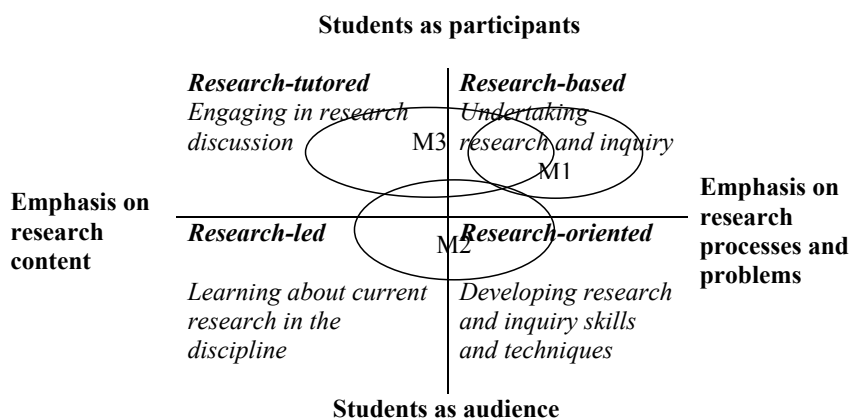
Most participants in the new program are in their third year in the bachelor's program. On average 200 students (8 percent of the approximately 2,500 third-year students) participate in different research projects each academic year. In the last two years, more than 400 students (of an annual enrollment of around 9,000 bachelor's degree students) entered the research-based learning program. Based on the regular course evaluations and some additional information from meetings with students and tutors, participants' first impressions of the program are very positive. Table 1 shows the first results of one evaluation of five specific components of the research-based learning project (scores are on a Likert-type scale; 1=disagree to 5=agree).

Faculty members are positive about the program. It offers them the experience of working intensively with highly motivated students for an extended period of time, which enables them to spot the potential of students to further their academic careers, for instance, as student assistants or in research master's or doctoral research programs. Another positive point mentioned by faculty members is that the program can inspire students to pursue a research career, even students who were initially skeptical about doing research. One of the staff members stated:

"The positive aspects for me were working with students on very interesting subjects, providing new and unexpected insights."

The academic quality of the students is reflected in several ways, including the increase in numbers of students participating in academic meetings (e.g., conferences and seminars) and even publishing in peer-reviewed scientific journals within their disciplines. To stimulate this even more, scholarships are granted for attending conferences or writing an article for a peer-reviewed journal. At least

FIGURE 1: The Nature of Undergraduate Research and Inquiry at Maastricht University



(Source: Healey and Jenkins 2009, 7)

Table 1: Students and Academic Staff's Perceptions of Development of Research Skills

Research Skill	Students (N= 34)		Academic staff (N=24)	
	Mean	SD.	Mean	SD.
1. Acquiring a substantial amount of new knowledge about the topic of inquiry	N/A	N/A	4.6	0.5
2.Improving skills in formulating research question(s)	4.1	0.8	3.7	0.8
3.Improving skills in gathering relevant information or data by using appropriate research methodology to answer the research question(s)	4.3	0.8	4.1	0.8
4.Improving skills in critically evaluating the applied research methodology	4.2	0.7	3.9	0.8
5.Improving skills in considering the practical and theoretical implications of the findings generated in the research	4.1	1	4	0.8

twice each year Maastricht University publishes a selection of the best of the student research papers written in that academic year. Maastricht University students also are well represented at the annual Student Research Conference in the Netherlands, organized by the Association of Universities in the Netherlands.

Another way in which the academic development of students is becoming increasingly visible is that many participating students who had never before considered them are now considering academic careers. Thus the research-based learning program is helping students explore their scientific ambitions and see themselves as part of the academic research enterprise.

Roadmap for the Future

Research-based learning has been carried out for two years and has been implemented in all faculties and in different academic programs. Staff and students are aware of this new learning environment, and student numbers are growing. The first evaluations show that the program has been successfully implemented and appreciated by both staff and students. However, there is room for improvement.

To maintain the program, it should be much more imbedded in the student curriculum, thereby making compensation for the staff more explicit and delineating more clearly what responsibilities the central university management has for the program and what responsibilities the faculties have.

Adjusting the model to accommodate a wider range of students also would require several adjustments. At the moment, the projects are custom-made and are supervised by highly qualified faculty members who are motivated by

the high quality of the students and by the special learning environment for these students. A wider range of students would require either more parallel projects in a curriculum that makes this difficult or students will have to work in groups on projects, whereby the average intellectual contribution of the student will decrease. This can frustrate the excellent students and also the staff members who prefer to work with excellent students.

Given the intensity of the research projects envisioned in the program, it is not suitable for all students. However, all students at Maastricht University come in contact with research within their disciplines, for example in the form of conducting small-scale research as part of groups of students (either duplicating existing research or conducting new research) or by discussing research articles in tutored groups. Two faculties have now revised their curricula, embedding more research elements in them, beginning in the first year. A third faculty now has introduced a research-based curriculum for all students, with the undergraduate research project available for the top 20 percent of the students in their third year.

Another improvement needed is the involvement of relevant social partners and businesses in the research projects. In some faculties this already has been implemented, but other faculties are still searching for appropriate partners. A third area for improvement is creating a community of learning around undergraduate research—creating a more structured environment for it. Therefore plans are under way for meetings in an informal setting between students and academic staff members, thus stimulating interfaculty cooperation and allowing the easier exchange of research knowledge and experiences.

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