

Math day – way of promoting math in scientific journals

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Abstract: This study observes how a math day-based intervention in master level research methodology education affects students' thinking about mathematics and also about mathematical methods in science. The experiment was constructed in three phases: short instruction, group work, and instant communication to the whole learning group. Utilization of the Learning material portal (LMP) and presence of two teacher coaches implemented our student-centric learning approach.

Standard student evaluation of teaching questionnaires were used for data collection. With minor limitations, the SET data was useful. The gathered feedback revealed that the concept was accepted. Even though the students observed some inconsistencies, they felt that the theme day was an inspirational and thought-provoking event.

With this approach, a highly theoretical subject like mathematical research appearing as sample articles did motivate our students to think in a new way. So the goal to encourage officer students to utilize math-related scientific knowledge in their thesis came closer to becoming reality.

Keywords: educational intervention, student evaluation of teaching

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1 INTRODUCTION

1.1 Math day

In the English-speaking world, Math Day is on March 14th (3.14) given its obvious link to π . One of the general objectives in this occasion is to give to participants an opportunity to enjoy the beauty of mathematics. Organizers of those events like to point out that the students don't have to be a math whiz to get involved. Participators are encouraged to 'have a go' and have fun learning. Unfortunately, some of the cultural issues are still left in many platforms, e.g., "the competition with prizes to be awarded to the top students and schools" (3P Learning, 2019). Some of the activities are less competitive and aimed at contributing everything from university teachers' material to high school students and student clubs, e.g., Image Math Day. (Yong & Orrison, 2008) In that specific approach, Mathematical Day celebrates mathematics



in daily life with positive images, experiences and emotions.

Likewise, the Finnish Math Day approach is targeted at junior high school- or high school-related activities. Math Day in Finland is celebrated on October 22 each year. The date was chosen to coincide with the birthday of the Finnish mathematician Rolf Nevanlinna (Nevanlinna, O. et al., 1983). In the theme leaflet at LUMA, the material Tuohilampi (2015) ponders: “What is math actually? Is mathematics every human’s right? Does mathematical thinking require flawless calculation, or can a person with strong logical thinking be considered a math expert even if he needs a calculator to deal with ordinary multiplication? Can math be a fun brain exercise?”

1.2 Master level studies in NDU

This study describes a short intervention made for master-level students in military technology at National Defence University in Finland. NDU is a training institution responsible for educating the future leaders of Finland’s armed forces. Master-level studies at NDU require prior educational qualifications and a commitment to a military profession. Due to profession- and skill-related demands, science, technology-, engineering-, and mathematics- (STEM) related courses are either integrated into professional disciplines or are relatively short and intense. Lectures and customized exercises are preferred for learning or re-learning basic knowledge in these disciplines. Only a few deep and pragmatic learning experiences, such as miniature laboratories or work-life related field experimentation, provide students a taste of concrete experiences in general technology. Mostly field-related practices enhance professional skills. In this paper, we characterize the methodological framework of military technology and show how to orient students into relevant methodological thinking. Moreover, we show how we have studied how students thought about the teaching. In the following, we present the general characterization of the Math Day project and after that we show students’ evaluation of the project.

2 Principles of Multidisciplinary

2.1 Literature review

There has been extensive discussion about the notions of multidisciplinary (MD), interdisciplinarity (ID), and transdisciplinarity (TD). The notions are both theoretically and practically very central. Present-day science and expertise the border

lines have become more and more obscure. There is proper need to understand how to orientate within complex and opaque environments in which solutions of problems presuppose knowledge from several different fields of science but perhaps also from several fields of practical expertise.

Basically the notion of interdisciplinarity means that two or more fields of science are integrated more or less deeply. The deepest integration integrates either notions, theories or methods of different fields of science together. However, the notion of interdisciplinarity also includes “external” integration. (Koskinen, 2015.) Klein (2017) refers to three basic ideas of interdisciplinarity: (i) bridge building, (ii) restructuring of two disciplines by taking only part of the existing discipline to achieve a new coherent theoretical whole, and (iii) possibility to subsume two (or more) disciplines under a new discipline which is also called transdisciplinarity. In the philosophy of science, there has been lot of discussion of how to extend or reduce theories (see, for example, Tuomela, 1973).

Testing hypothesis or answering research questions by borrowing methods from other fields of science is called *methodological interdisciplinarity*, which is closely related to theoretical interdisciplinarity, in which analysis of some specific problems in the integration of notions and results of different disciplines are integrated. However, these are deep forms of integration which presupposes unification of linguistic and theoretical foundations of the theories. However, the notion of multidisciplinary is theoretically less demanding. As OECD classification says, it is merely “[j]uxtaposition of various disciplines”. (Klein, 2017.)

Because of the variety of possibilities in integrating different fields of sciences, there is a need for systematic analysis of the situation, which is essentially a philosophical task. Fortunately, there is a quite long tradition in science education to consider questions related to the philosophy of science. Philosophical questions are present in all teaching, both in curriculum planning and in substance teaching. This is emphasized by Matthews (2006, 342) as follows: “These questions encompass educational ones about the place of science in the curriculum, and how learning science contributes to ideals of an educated citizen and to the promotion of a modern and mature society. The questions also cover the subject matter of science itself. What is the nature of science? What is the status of its knowledge claims? Does it presuppose any particular world view? The first category of questions constitutes standard philosophy of education (PE); the second category constitutes philosophy of science (PS) or history and philosophy of science (HPS).”

The philosophical questions are even more important when multidisciplinary, interdisciplinarity and transdisciplinarity questions are considered. In this paper we will focus our attention to one specific field, namely military technology, which has also more general interest. (Koskinen & Mäki, 2016.) Military technology is closely connected to technology, but it cannot be identified with engineering science. Besides technology, it is connected to, among others, user research, pedagogy, and leadership, which are all present in research projects of military technology.

Military technology is in balance with the examples given by Klein (2017) who speaks about “interstitial cross-disciplines” or hybrids like social psychology, economic anthropology, political sociology, etc. Moreover, she explicates occupational disciplines, like social work or nursing, which generate new interdisciplinary fields. In fact, military technology is very similar as the disciplines mentioned by Klein, but, moreover, military technology is, at the same, occupational discipline.

Such research and study fields are of central importance in present-day society. However, there are no generally accepted methodological or theoretical approaches. There are several different kinds of approaches which are based on some practical reasons. The solutions accepted vary from case to case. It seems that there is no general epistemic or theoretical foundation which explains the accepted solution, even if in very many cases there is good justification. For example, the very central notion of “epistemic community” is not easy to specify (Klein, 2017; Koskinen, 2014).

2.1 Applying Multidisciplinary

In this paper, we study some specific question of methodology of military technology. More specifically, we will only consider questions in which “formal structural relationships” are taken under study. In general, examples of such approaches are fields like electromagnetics and cybernetics. In these, mathematics plays a central methodological role. However, mathematics does not refer to some specific mathematical method, like calculus, but more generally, a logico-mathematical method of structuring problems (Mutanen, 2019).

In methodological study, we are interested in the logico-conceptual structure of scientific research. The intention is to grasp the rationality of the research process. The methodology shows that conceptual and factual cannot be separated and that conceptual (mathematical) knowledge is indispensable in science. (Hintikka, 2007.)

Mathematical knowledge especially is an essential factor in experimental research: mathematics is not merely a tool, but rather, an essential factor in experimental questioning. More generally, mathematics is a general methodological approach both in quantitative and qualitative research. (Aczel, 2006.)

In methodology, a central aim is to characterize the rational reasoning on which scientific research is based. There are several different kinds of reasoning methods such that there cannot be found a single method which could solve all the problems as Feyerabend (1999, 19) says while justifying his methodological principle of “anything goes”. However, in philosophy of science, there is also a search for general rational principles that are more general than specific methods referred to by Feyerabend. A well-known method is the method of analysis and synthesis, which is philosophically interesting and which also has methodological content. Aristotle characterized this as *the general method of human deliberation*. In this paper, we have these kinds of logico-mathematical methods in mind (more precisely, see, for example, Hintikka & Remes, 1974; Niiniluoto, 2018).

3 Methodological approaches

3.1 General principles

In universities, a central intention is to teach students fundamental principles of scientific thinking. To achieve this, it is important to teach different methodological approaches that can be chosen. However, one aim is to teach that different kinds of problems presume different kinds of methods and what kinds of principles there are to make the choice of method. The aim is to get students to understand principal ideas of how research questions are formulated and answered.

In the military context, most of the courses include a number of learning objectives, some of which can be considered tacit knowledge, which is difficult to measure without real [military] activity and the real threats associated with it. Likewise, success in methodology education comes true in students’ theses and does not have a value of its own. The assessment in methodology education has limited use but may support research and provide hints on how to develop the practice itself.

From a constructionist perspective, attitude change results from new information being activated. This change reflects a change in the underlying memory representation of the attitude in question. Attitudes can be measured, e.g., by using

explicit self-report instruments or implicit response-time-based measures. These differences in attitude conceptualization and measurement bear on the theoretical understanding of attitudinal change. (Bohner & Dickel, 2011).

According to Schreurs and Dumbraveanu (2014), the responsibility of educators is to create learning environments that support learning activities conducive to realizing the intended learning outcomes, ensuring that the learners become active creators of knowledge or even co-responsible for knowledge creation. It is not only students that need diverse new skills. Teachers also need new skills and attitudes. Projects with research in mind would open teachers to attitudinal change.

3.3 Research viewpoint for the case

In methodology lecture courses, our intention has been to search for fruitful approaches to educate by infusing mathematical methods and, especially, logico-mathematical thinking into students of military technology. To achieve the goal, we have planned lecture courses in which students read mathematically-oriented methodology texts and based on the text students structure research problems.

In military technology there is need for a multitude of methodological approaches. Special technical problems presuppose detailed knowledge of natural sciences and questions about the machine-user relationship presuppose qualitative methods, like game theory or graph theory and questions emphasizing leadership presuppose several different kinds of methods, including game theory and logico-qualitative methods (Strijbos, 2017).

Tuohilampi (2015) ponders such attitudinal issues as: “Are there students in the class who consider themselves completely non-mathematical?” and “Where did this idea come from and how could that be changed?”

This study considered two research questions:

1. Does Math Day provide a new contribution to methodology education, especially for new kinds of learning?
2. Can standard student evaluation of teaching (SET) be utilized in a short, time-limited intervention and can SETs assist in making corrective steps for the future?

4 Learning activity in Math Day

4.1 General principles in case

To orientate students for the group work session, we organized an introductory session in which foundational ideas were presented. The theme was how Bayes' models can be conducted from a straightforward case. The introduction ended with a simple description of how a group work session will be arranged. In the Math Day tasks, material was handed out to each group. Two groups were working on the same problem and before presenting their findings, the two groups negotiated what kind of findings they ultimately attained. Only one presentation per theme was given to the whole study group.

4.2 Studying material

As orientating students to the group work was problematic, we handed out a paper which all the students had to read before the session. The paper established common ground for the group work. Each of the groups was focused on their own specific problem. However, as mentioned above, for each problem, there were (at least) two groups working on it. The general theme was methodology and the main focus was probability theory, especially Bayes theorem and its use in science. However, the texts also included material on decision theory, in which graph theory plays a central role and the theory of probability plays minor role.

5 Student evaluation of the experiment

Feedback from students with SET provides the necessary information for instructors regarding how to streamline teaching protocols, but it provides only a few tools for making significant educational improvements. Therefore, development work in this field requires more than just empirical evidence of learning results and students' wishes and opinions. Technology development also offers this era new opportunities to organize education in a rewarding way and real innovations in this area require more than gathered formal feedback. The responsibility to re-engineer education in a creative manner creates a continuous challenge for instructors and organizations.

5.1 Data collection

Standard local SET questionnaires in Moodle were used for data collection, data comparisons, and data storage. Observations focused on common course impressions. Personal estimates of learning results, motivational aspects, and free text impressions were analyzed. The questionnaires involved a five-step Likert scale. When the quantitative data from the questionnaires was combined with the qualitative data—such as data gathered using open-ended questions, participant observations, and interviews—the questionnaires’ validity improved and our results became more accurate.

Table 1. Student evaluation of the experiment

9 Relevant evaluation themes from the Standard Questions in NDU’s SET	Average value
I achieved the goals set for the course.	3.8
I was an active learner.	4.0
The learning atmosphere supported my learning.	4.3
The instructors mastered the facts.	4.5
My overall grade for teachers	3.8
The course provided me with new knowledge; it was not just a repetition.	4.3
The assessments supported my learning.	3.8
The LMP was utilized well.	3.9
My overall grade for the course as a whole, on a scale of one to five.	3.1
Summary (N= 15)	

In Table 1, SET data is listed according to nine of the most meaningful issues from 21 questions. Additional work was needed to clarify conversations and for other kinds of qualitative data with which instructors can determine students’ opinions of the intervention’s outcome.

6.2 Regards to Course Enhancement

It provided a structure useful for long-term educational development. Such development is typically iterative work, and real educational improvements can be obtained with the persistent cooperation of team members. Aside from the ability to focus on practical tasks, this method focuses on theoretical problem analyses, and it in turn helps scholars consider meaningful issues in the field, e.g., commonly known evidence and knowledge of teamwork challenges.

This means that the role of students should entail considering more than what SET means via the analysis of such data. Space is needed for clarifying conversations and

for other kinds of qualitative data with which instructors can determine problem areas. The “voice of customers” is valuable, but in educational development, space is also needed for new approaches. For such work, simplified feedback from students seldom forms the primary input. Empirical evidence can assist in determining important problem areas but may be insufficient for determining the most prominent targets for educational development.

7 Discussion

The master thesis is central study work during master studies. It demonstrates the scientific thinking students have learned during their studies. Seminars and other guidance activities orientate students to do their master thesis. It is pedagogically justifiable to do some of these as group work. In genuine leadership, it is understood that students have their responsibilities and teachers make efforts to support students in their challenges. The appropriate assessment of teaching and learning through student feedback helps teachers evaluate their teaching orientations and pedagogical methods (e.g., Guskey 2003).

Attitudinal issues were observed, but only informal discussions with students reveal something new in the way of thinking of mathematic knowledge as a tool for military practice or research. Information in SET was too simple to foster perception of any proven change.

Conclusions

This study initially investigated the first experiment with a relatively small student group. Typically, group-based tasks are given when resources for in-person lectures are limited. Therefore, guidance and clearly articulated goals for groups are needed to ensure success in group-based learning (Hammar & Chiriac, 2014). In this case, two instructors available to help 10 groups was appreciated and ensured that students stayed engaged in the task at hand without wondering about unclear messaging or other obstacles.

While blended learning continues to be regarded by most students as less effective, it can nonetheless generate satisfactory results if sufficient time is given over to planning and there is clarity with regards to the sharing of duties. Students at NDU still preferred face-to-face courses even though they would otherwise have more freedom to schedule their studying.

Student evaluations—including measurements of satisfaction regarding applied teaching—are important because they can impact motivation and thus enhance student success and completion rates. Measurements of satisfaction are also valuable to institutions because they can be used to evaluate courses and programs and—to a certain degree—to predict student attrition rates.

The standard local SET questionnaire utilizing Moodle was not created for this study. However, additional measures made it a valuable quantitative tool. It is important to listen to students' voices, but when creative steps are taken, such signals are not enough. Good student feedback does not mean that all is fine. In the future, teachers with multitasking leadership roles will be a necessity, as blended learning environments will occupy more instructional space. For coordinative and quality-focused reasons, the teacher's role in such learning arrangements will be in need of constant self-evaluation.

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