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Abstract

The National Defense University (NDU) trains officers to develop their academic and professional skills. To accomplish this, the university offers two mandatory courses on methodological training for military technology students for master level education. The first course was theoretically oriented, and the second course was practically oriented. These both master-level methodology courses emphasize practice oriented mathematical skills, which officers use in their operative decision-making and statistical analysis. This study focuses on student-centered learning methodologies linked to teachers' observations from current and previous course implementations. Results in this study described the outcome from the first run of the revised curriculum. We collected data from students' course reports and the university's standard student evaluation of teaching (SET). According to the SET, the course 2 which was practically oriented course, where groups worked on more significant projects gained higher value among students. In conclusion, we recommend that teachers continue using student-centered learning methodologies to technical students as much as possible. Theoretically underscored courses should also contain more practical examples.

Keywords: *distance education, flipped learning, learning by doing, research methodology, student-centered learning*

Introduction

Theoretical knowledgebase is an essential aspect of technical teaching. However, in mathematics courses theoretically oriented courses require intense content design to be inspiring for students. Is it just about enhancing students' thinking skills, particularly abstract thinking? As late as the early 20th century, for about 50 years, Neovius-Nevanlinna mathematics textbooks were used almost exclusively in high schools. These books were considered consistent but demanding (e.g., Lehto, 2004). At that time, learning outcomes were typically such that one-third of students did not even reach the accepted grade. According to Nevanlinna (2021) the learning goals implemented in these textbooks were possibly too abstract for school children at that time. Nowadays mathematical knowledge is an essential component of experimental research. It is not merely a tool, but a vital part of exploratory questioning and a general methodological approach used in both quantitative and qualitative research (Aczel, 2006). Earlier in NDU, in officers' methodology education, master-level students appreciated a short, one-day-long intervention experiment around Word Math Day (Rissanen & Mutanen,

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2019). In general, master-level technical students in NDU are open to any non-traditional math education.

In 2020, NDU's curriculum for master students changed a little bit, and some courses merged. The standard general line only has subject specification for the master thesis and formal support for discipline-specific knowledge linked to the thesis. According to the update in the curriculum, the Department of Military Technology gives two research methodology courses that support each other. This article presents those two updated formally Bologna process-based military technology courses where mathematical knowledge and practical skills are major learning items. The first course gives basic knowledge about traditional statistical analysis tools and includes a short session on how to make research in general. The second course teaches tools that would help to evaluate research settings. The preliminary modeling usually works as an advising tool during technical research. Therefore, the first course is more formal and theoretically oriented than the second course. This study aims to understand how students responded towards each of the two research methodology courses, namely *Methodology course 1* (theoretically emphasized distance learning and class learning course) and *Methodology course 2* (practically emphasized distance learning alone*)*. While the first course is more theoretically oriented, the second one is more oriented towards the technical aspects of practical research methodology. As the COVID-19 pandemic changed routines, the first course used more lecturing, while the second course employed more distance education principles.

Research Aims and Questions

The purpose of this study was to investigate the learning efficiency and also student satisfaction in general between these two courses.

RQ 1: Students 'attitudes towards mathematics as a research method and how do students' responses vary between these two courses?

RQ 2: How gained results of student responses should be noticed in future course design?

Theoretical Frames

Student-centered Learning

In student-centered settings, the responsibility for learning shifts naturally falls to the student (Wright, 2011). Students cooperate and take intense responsibility for their studies. Master-level students majoring in scientific subjects on NDU's technology program have different (individual) instructional needs. Therefore, the current study explores how relatively practice-oriented courses affect students' motivation and attitudes towards physics and technology as professional tools. On the other hand, the more traditional starting course would be a good reference for the study. Both courses include support for individual learning.

The literature suggests that student-centered learning can be approached e.g., using project-based learning (PBL). In the 21st century, this concept is used to revise curriculums. With a student-centered learning approach, students can experience real-life situations inside the classroom (or equally in their distance learning premises). Instructors are supporting

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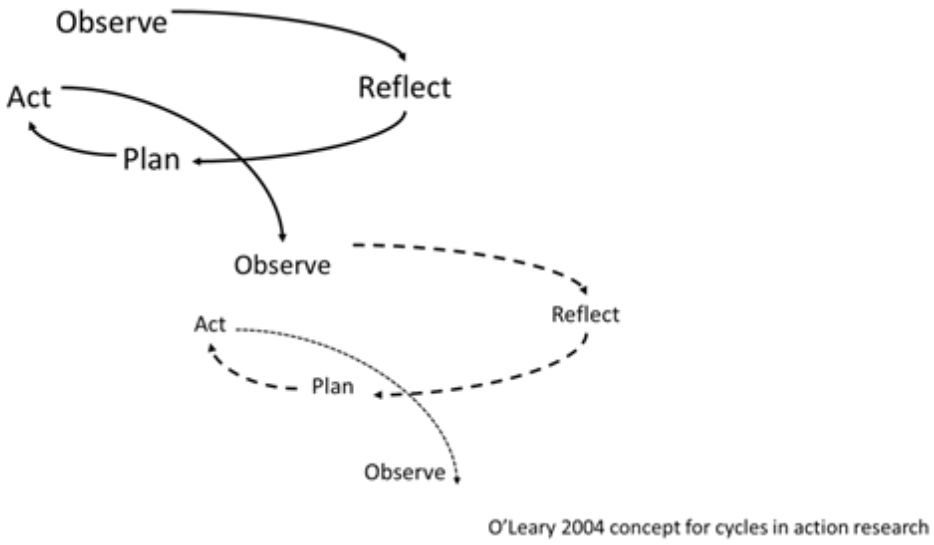
students on their journey to achieve learning. At all academic levels, small groups or teams working on projects are a mandatory arrangement. However, this arrangement alone does not allow higher levels of critical thinking. A traditional "one-size-fits-all" approach will not work for all types of education (Zmuda, 2009).

Action Research

Action research encourages researchers to participate in everyday life of the focus organization. Attendance combines with and influences subject analysis (Kemmis & McTaggart, 2013). Processes are not as straightforward as the sequential parts of independent design, operation, observation, and reflection. The described modules may overlap, and the original plans may become irrelevant based on experience and new information. Activity-related research can be reflected as an experiential learning approach, with sophisticated methods and enhanced knowledge interpretations based on the understanding of previous cycles (O'Leary, 2004; see Figure 1).

Figure 1
Action Research Cycle. Ideas of Continuous Research and Enhancement



Flipped Learning and Distance Education

A case study is a way of conducting research. It can be called a qualitative research approach, but a case study is not synonymous with qualitative research. The case study approach is not in itself a standalone research method. It isn't easy to give a general or comprehensive definition of a case study because there are different types of case studies (Crowe et al., 2011). In this work, we use it as a research strategy.

The flipped classroom refers to teaching with active and blended learning styles. The learning material is provided before any handling in lectures. This technique leads to integrating face-to-face and online teaching techniques enabling students to engage in

https://doi.org/10.33225/BalticSTE/2021.135

meaningful and communicative learning and critical problem-solving. Therefore, course instructors may act as facilitators, guiding students in the discussion individually or in groups during class time. The implementation of flipped learning in a higher education course improved students' achievements and attitudes towards learning (e.g., Garrison & Akyol, 2009).

Ganesh (2021) presents how flexible a Moodle platform can be for this type of flipped learning. In his experimental videos and other study materials, he distributed texts through MOODLE platform. Learning targeted student-centered learning was organized underlining working in pairs or small teams.

Distance education has a long tradition, especially in Australia and the US Navy (e.g., Arenas, 2005). Due to the sudden and life-threatening COVID-19 pandemic, a large part of traditional university education has stopped. In Italy, Giovannella (2021) studied how the rapid transformation to distance education as the only choice, affected students' opinions. Although students seem to miss physical campus activities, the switch from physical to virtual environment was taken in a positive way. Moreover, a large part of the present generation of university students seems to be ready for novel educational activities.

Research Methodology

Data Collection

We used standard local SET questionnaires in PVMoodle for data collection, data comparisons, and data storage. Observations focused on common course impressions. In addition, we analyzed personal estimates of learning results, motivational aspects, and free text impressions. The questionnaires involved a 5-point Likert scale. When we combined the quantitative data from the questionnaires 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. For Figure 2, we selected only eight most analyzable questions from the standard questionnaire.

The answers gathered are to the following questions or notices:

1) I achieved the goals set for this course.
2) I was active during the course?
3) Was the overall ambiance during the course supportive of your studies?
4) How well did the instructors master the subject matter of the course?
5) Give an overall grade for the instructors.
6) Did you learn new information/skills?
7) Did the evaluation of this course support your learning?
8) Give an overall grade for this course.

The number of students who voluntarily participated in the evaluation was 21 for the course 1 and 12 for the course 2.

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Research Material

Course implementation
Teaching in the first course (Hybrid course with class learning and distance learning)

The first course, which included research practice and statistical methods, was organized into two parts. According to the course plan (a detailed plan expressed in the weekly program), mathematical content and statistical methods were taught intensively in two-week period. Teaching methods included lecture teaching, illustrative demonstration examples, and voluntary and supervised practice. Instead of fully present or distant education, a hybrid version was utilized. Therefore, remote participation was possible but not too comprehensive. The assessment consisted of five sets of tests based on scored exercises (i.e., 23 calculation tasks), of which 60% of the maximum points had to be obtained for the approved performance. Along with the course progress, 21 out of 22 students passed this formative test. The one who failed had an accident which prevented further participation along the spring term. All students responded to the feedback questionnaire after the professor's reminder. This course aims to acquire the skills related to Pro Graduate research and consists of exercises and knowledge creation in group works. Observations from student evaluation of teaching (SET) data complemented this knowledge.

Teaching in the second course (distance learning)

The second course, which consisted of practical modeling methods and simulation tools, took place during spring term in three weeks period. The instructional structure of course 2 was similar to the previous years' simulation and modeling course, which had been carried out eight times with good feedbacks from students and with only minor modifications. It consisted of three overlapping teaching methods, namely distance lectures, supervised exercises, and unsupervised exercises. At the end of the course, student groups presented their unsupervised exercises. The final report consisted of documentation and the functional version of the group's own specific modeling realization. The course used simulation and mathematical modeling as a research method.

The first week (in the 3 weeklong course module) content was about random numbers and distributions, IF-THEN structure and reasoning, Lanchester equations, Markov chain, Monte Carlo simulation, and Queuing theory. Two distance lectures on machine learning, artificial intelligence in the Defense Forces, and general machine learning methods and the skills required for their use were also presented. Learning exercises called seminar work were also published. Most of the seminar work topics came from the students themselves in connection with their master's theses.

Course content in the second week was about mathematical models to support decision-making, value tree analysis, analytical hierarchy process (AHP), and optimization methods.

In the third course week, students focused on completing shared homework as well as seminar work. Students were given personal guidance using remote connections and according to their research needs. By the end of the course, the exercises were complete. In the last teaching event, the students presented their seminar work in groups.

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The course aims to help students understand the methods taught and apply them. Based on the questions actively asked by the students, the work done in the final seminar, and the student feedback, we can conclude that the goals set at the beginning of the course have been met.

Learning took place remotely using Zoom and PVMoodle. Also, additional communication was done via Skype and email. Using Zoom for cloud-based video conferencing is not new (e.g., McCoy, 2015), but due to its flexibility to enhance distance education during the COVID-19 pandemic, both courses in this study utilized where applicable.

Research Results

Analysis Based on Student Feedback

Students are familiar with the National Defense University's standards for student evaluation of teaching (SET). However, the validity of student evaluation of teaching (SET) in universities depends on which purpose it has been utilized. An early and limited study made in the UK context (Shevlin et al, 2000) demonstrates that teaching ability can influence evaluations. Moreover, they name other factors like student profile and the physical environment. To overcome some of the side effects, they included new elements related to the lecturer's charisma. With a student-centric approach, opinions of teachers' charisma become less critical. On the other hand, e.g., Athiyaman (1997) claims that student satisfaction and service quality could be a way to construct a value from the SET data type of information.

Feedback data from students with SET provides the necessary information for instructors on how to streamline teaching protocols, but it gives 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 genuine innovations in this area require more than gathered formal feedback. The responsibility to re-engineer education creatively creates a continuous challenge for instructors and organizations. For that purpose, student reports and written statements in SET are indirectly utilized.

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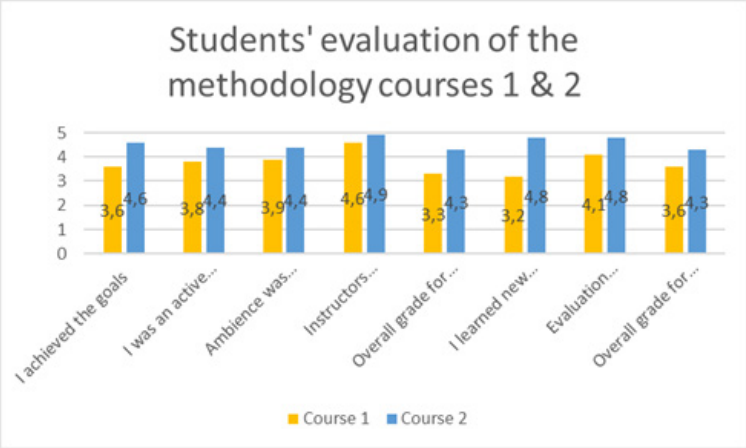
Figure 2
Students' Evaluation of the NDU's Research Methodology Courses 2021 (Course 1, N:21; Course 2, N:12)



Discussion

Student feedback from Course 1 was generally little over average in factors describing student activity. The professional skills of teachers were good. On the other hand, based on the feedback survey, it is worth adding mathematical details to the teaching material in the learning material portal. This is a clear development plan for statistics in the subsequent implementation. The feedback from the Courses 1 and 2 was at an excellent level. However, scheduling is still worth refining for the courses. Both courses included exercises. The statistical methodology in both courses was demanding but also relatively straightforward to apply. On the other hand, according to students, modeling had more connections to daily life. But also, the teachers needed more detailed mathematical formulation of the set problem or intermediate processes towards the solution. According to the data presented in Figure 2, the overall attitude toward learning was higher in the later course (2, practically oriented student-centered course). Due to nine lacking answers in course 2, the numeric data can be utilized for profiling with other data. According to the SET data with open question answers, course 2 was perceived more student oriented. In this course, students could suggest their final works and worked collaboratively under their teacher's supervision. Because of this, students appreciated it more.

Conclusions

A balance between rigor and practice is essential. Students at NDU have always wished for more practice-based examples. Therefore, it is understandable that they prefer a course that emphasizes practice. Distance learning does not mean less student satisfaction. Results showed that students were generally more interested in practice-oriented student-centric education. This does not mean that theoretical education is less valuable. On the contrary, the results showed that educators could inspire students to value

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theoretical knowledge if they demonstrate the practical applications of such knowledge. Theoretically emphasized course (course 1) should also include more real-life related examples. However, more research is required to deliver theoretical knowledge in an inspirational and student-friendly manner effectively.

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Declaration of Interest

Authors declare no competing interest.

References

Aczel, A. D. (2006). *The artist and the mathematician: The story of Nicholas Bourbaki, the genius mathematician who never existed*. Thunder Mouth Press.

Arenas, F. J. (2005). *Military distance education: The Navy College Program for Afloat College Education (NCPACE) continuing effectiveness evaluation*. The George Washington University.

Athiyaman, A. (1997). Linking student satisfaction and service quality perceptions: The case of university education. *European Journal of Marketing, 31*(7), 528–540.

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology, 11*(1), 1–9.

Ganesh, V. N. (2021). A quantitative investigation of student performance in a peer assisted flipped classroom model. *Journal of Engineering Education Transformations, 34*, 186–190. http://dx.doi.org/10.16920/jeet%2F2021%2Fv34i0%2F157133

Garrison, D. R., & Akyol, Z. (2009). Role of instructional technology in the transformation of higher education. *Journal of Computing in Higher Education, 21*(1), 19–30.

Giovannella, C. (2021). Effect induced by the COVID-19 pandemic on students' perception about technologies and distance learning. In Ó. Mealha et al. (Eds.), *Ludic, Co-design and tools supporting smart learning ecosystems and smart education* (pp. 105–116). Springer.

Kemmis, S., & McTaggart, R. (2013). *The action research planner: Doing critical participatory action research*. Springer Science & Business Media.

Lehto, O. (2004). *Oman tien kulkijat. Veljekset Vilho, Yrjö ja Kalle Väisälä* [Walkers of their own way. Brothers Vilho and Kalle Väsälä] (p. 397). Otava.

McCoy, K. (2015, March). Using Zoom, cloud-based video web conferencing system to enhance a distance education course and/or program. In *Society for Information Technology and Teacher Education International Conferenc*e (pp. 412–415). Association for the Advancement of Computing in Education (AACE).

Nevanlinna, H. (2021, May 23). Lukijan mielipide | Matematiikassakin pärjää tiettyyn tasoon saakka opettelemalla erilaisia sääntöjä [Reader's opinion | Even in mathematics, you can get to a certain level by learning different rules]. *Helsingin Sanomat*. https://www.hs.fi/mielipide/art-2000007982456.html

O'Leary, Z. (2004). *The essential guide to doing research*. Sage.

https://doi.org/10.33225/BalticSTE/2021.135

Rissanen, A., & Mutanen, A. (2019). Math day–way of promoting math in scientific journals. *LUMAT-B: International Journal on Math, Science and Technology Education, 4*(1), 19–29. https://journals.helsinki.fi/lumatb/article/view/1132

Shevlin, M., Banyard, P., Davies, M., & Griffiths, M. (2000). The validity of student evaluation of teaching in higher education: Love me, love my lectures? *Assessment & Evaluation in Higher Education, 25*(4), 397–405.

Wright, G. B. (2011). Student-centered learning in higher education. *International Journal of Teaching and Learning in Higher Education*, *23*(1), 92–97.

Zmuda, A. (2009). Leap of faith: Take the plunge into a 21st-century conception of learning. *School Library Monthly, 26*(3), 16–18. https://eric.ed.gov/?id=EJ860981

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