Geomatics Field Course for Norwegian Civil Engineers: A Norway-Canada Collaboration

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ABSTRACT: This paper presents a proposal for integrating a Geomatics Field Course into the Civil Engineering program at the Norwegian University of Science and Technology (NTNU) in Gjøvik. The Geomatics Field Course is specifically designed to meet the changing demands of the engineering industry by providing students with applied experiences and a broader perspective of social and environmental implications. Although the current geomatics program at NTNU in Gjøvik is based on a solid theoretical foundation and a practical focus, pedagogical innovations are needed to further enhance students' skills, promote cross-disciplinary learning, and provide diverse insights into geomatics issues. This paper outlines the rationale, structure, and critical considerations for the implementation of the Geomatics Field Course. The strength of the current geomatics program at NTNU in Gjøvik includes a structured curriculum, practical relevance, and integrated components. There are opportunities for improvement including broadening practical experience, developing soft skills, and further collaboration with industry partners. To address these issues, the paper draws on the joint field course experiences held with the University of Winnipeg; experiences which highlighted the benefits and considerations of project-based learning and multi-disciplinary teamwork. The proposed Geomatics Field Course aims to fill current gaps in the curriculum and provide students with an intensive learning experience that builds on their knowledge and skills from the previous year of study. The course will emphasize project management, extensive field experience, soft skills development (including communication and teamwork), and complex problem-solving. While acknowledging the challenges associated with implementing a field course, such as scheduling and cost, the authors strongly emphasize the need for such a program to increase students' career readiness. Furthermore, it is suggested that the proposed course approach, which combines project-based learning and international collaboration, could serve as a model for other engineering programs in Norway.

1 INTRODUCTION

Civil engineers design, build and supervise infrastructure projects and systems based on the Conceive-Design-Implement-Operate (CDIO) process (Klakegg et al., 2019). Geomatics lies between civil engineering and the real world, playing an important role from the early stages of design to the final as-built mapping environment (Owen et al., 2009; Silva, 2020). CDIO is developed through technical knowledge and reasoning, personal and professional skills, teamwork and communication, which all are applied for business and societal benefits (Klakegg et al., 2019). The increased complexity of real-world problems means expanded social responsibility by engineers so that infrastructure is adapted to natural disasters, population growth and climate change (Tougwa, 2020); this also means preparation to meet these challenges with comprehensive geospatial skills.

Broad calls have been made to refine teaching and learning strategies to improve student competencies in understanding, assessing, and actions when dealing with complex problems (Kricsfalusy et al., 2016). This requires pedagogical innovations to ensure experiential learning, multidisciplinary training, professional development, and networking. For the geomatics discipline, these pedagogical innovations also include increased spatial knowledge and skills aligned with future job requirements.

Much has been written about how these pedagogical advancements can be achieved effectively and efficiently through residential field courses (Gold et al., 1991; Warburton et al., 1997; Storie and Bugden-Storie, 2010; Easton and Gilburn, 2011). Residential field courses (multi-day, remote experiences) incorporate active pedagogy which includes student-centred learning and diverse activities on real-world problems within a natural context (Warburton et al., 1997). As such, practical field-based learning has a long history within university disciplines of geography, geology/geosciences, biology, anthropology, art history, urban studies, etc. For example, in 1896, Chamberlain documented how students should create “by [their] own effort, an independent assemblage of truth” (1896; p848) when understanding Earth inquiries as an important tenet of their studies (Pyle, 2009).

With the purpose to increase students’ preparedness for future challenges (Klakegg et al., 2019), the aim of this paper is to outline a civil engineering Geomatics Field Course for Norwegian University of Science and Technology (NTNU) Gjøvik undergraduate students in the land surveying and GIS streams. This outline is developed through a critical reflection of (a) NTNU Gjøvik civil engineering geomatics education, and (b) collaborative field courses offered by NTNU Gjøvik and the University of Winnipeg (UWinnipeg) in Churchill, Manitoba, Canada and Raubergstulen, Oppland, Norway. By reviewing the existing geomatics education at NTNU Gjøvik, the link between this proposed Geomatics Field Course and the previous skills/knowledge obtained in the program can be identified. The course planning, design and considerations in a Norwegian setting will be drawn from the reflection of the collaborative experiential learning courses.

2 NTNU GJOVIK GEOMATICS CIVIL ENGINEERING PROGRAM

This section starts with a description of the current state of the Geomatics program in civil engineering, followed by identification of the program’s strengths and limitations. The Geomatics program at NTNU Gjøvik offers students a comprehensive and structured course of study as all Norwegian undergraduate engineering programs are regulated by the Ministry of Education and Research, and the content of general subjects is stipulated by the National Council for Engineering Education. The three-year program is designed to offer students a solid foundation in geomatics, giving them the knowledge and skills needed to excel in a dynamic and continuously expanding professional discipline. Students receive a total of 180 credits during the program which ensures that students are not only well-versed in the core principles of geomatics but also have the option to investigate speciality areas within the subject. Each year, the curriculum is divided into two semesters, each with 30 credits (Table 1). The semester-based structure of this program promotes concentrated study, promotes cohort relationships, and allows students to go deep into their studies. It also facilitates task management and ensures that students have ample time to process content and get practical experience.

Table 1: Geomatics Course Progression Flowchart by Year

	Autumn Semester	Spring Semester
1st Academic Year	GEOM1130 - Introduction to geomatics	GEOM1210 - Land Surveying Calculations
	GEOM1140 - Geographical Data	IDI1002 - Front-end web development
	IMAG1002 - Mathematics for engineering 1	IFYG1000 - Physics
	INGG1002 - Programming, numerical mathematics and security	IMAG2023 - Mathematics for engineering 2 C
2nd Academic Year	EXPH0600 - Examen philosophicum for Engineers	GEOM2410 - Geodetic Control Networks
	GEOM1320 - Applied geomatics	GEOM2420 - Terrain models
	IDG2004 - Information Structures and Database Systems	GEOM2430 - Geographical infrastructure and information processing
	ISTG1002 - Statistics	GEOM2440 - Geographical data capture
3rd Academic Year	GEOM2910 - Bachelor Thesis - Geomatics (1/2)	GEOM2910 - Bachelor Thesis - Geomatics (2/2)
	BYGG1101 - Civil Engineering*	INGG2301 - Engineering Systems Thinking*
	GEOM2510 - Construction Survey	
	GEOM2520 - Satellite Geodesy	
	GEOM2530 - Laser scanning	
	GEOM2540 - Geographic Analysis and Remote Sensing	
	GEOM2550 - Geomatics Project Work	
	IMAG2100 - Mathematical methods 3	

**Optional Course*

Building a solid foundation is the focus of the first three semesters (1-3) of the Geomatics program. While the whole program is designed to offer a comprehensive geomatics education, the first three semesters offer courses devoted to fundamental subjects, establishing a strong understanding of key concepts and processes (Table 1). In these semesters, students are introduced to the engineering profession and gain primary knowledge in science, information technology, and geomatics; courses that combine theory and practice. For example, in the first semester, there is an introduction to the theoretical and practical aspects of geomatics, followed by hands-on practice with key equipment and software for spatial data management. Exposure to equipment takes the form of, for example, the use of survey tools for an hour or two on campus grounds while spatial data management is practiced in the computer lab setting. Students connect theory and practice by delving into the use of Norwegian geographic data, which includes data quality standards, conducting experiments, relevant data formats, and adept data presentation and analysis.

During the second semester, students improve their existing geomatics knowledge with physics, programming, and web-development. For example, competency in front-end web development includes the creation of visually appealing websites, using HTML, CSS, and JavaScript, that are needed for dynamic map delivery. In the third semester, students refine their mathematical modelling and problem-solving skills as well as gain proficiency in using database-based simulation and analysis tools. Students delve into principles and skills for real-world land surveying projects using advanced measurement instruments and they acquire knowledge of database systems and management (Table 2). Moreover, the students engage in a course promoting critical thinking and ethical reflection, preparing them to contend with complex philosophical questions encountered within the geomatics professions. Starting in the fourth semester, students immerse themselves in specialized geomatics subjects that bolster their professional competencies. Critical areas include geographic infrastructure and information processing, terrain models, geographic data capture, and basic network analysis.

Table 2: Knowledge, skills, and competencies of current Geomatics courses

<table>
<tr><th>Knowledge</th><th>Skills</th><th>General Competences</th></tr>
<tr><td>Data collection, systemization, storage, management, analysis and presentation of geodata</td><td rowspan="2">Apply geomatics knowledge and relevant results from research and development work to practical and theoretical issues and make reasoned choices</td><td>Aware of environmental, ethical, and financial consequences in relation to their own work tasks within the geomatics industry</td></tr>
<tr><td>Research and development</td><td>Plan and carry out varied tasks and projects that extend over time, alone and as a participant in a group, and in line with ethical requirements and guidelines set in the geomatics industry</td></tr>
<tr><td>Update knowledge through literature searches and contact with professional environment</td><td rowspan="2">Reflect on their own geomatics practice carried out with relevant software and equipment for geomatics engineers and adjust this under guidance</td><td rowspan="2">Convey geomatics professional knowledge to people in adjacent disciplines with whom the geomatics engineer collaborates, both in writing and orally in Norwegian and English</td></tr>
<tr><td>Geomatics industries, working methods and cooperation with other industries</td></tr>
<tr><td>Current practices for the collection, distribution, and presentation of geomatics data (including web-based)</td><td>Basic skills in modelling, collecting, and structuring geographical data and can present this orally and in writing</td><td>Have a conscious relationship with their own knowledge and skills, have respect for other subject areas and professionals and can contribute to interdisciplinary collaboration</td></tr>
<tr><td>Applicable laws and standards in the field</td><td rowspan="2">Good skills in the use of market-leading software and equipment within GIS, modelling and land surveying and can argue for the techniques used both in writing and orally</td><td>Participate actively in geomatics discussions and can share this knowledge and skills with others and can contribute to the development of good practice in the geomatics industry</td></tr>
<tr><td>Market-leading software and equipment</td><td>Aware of information security issues</td></tr>
</table>

Students can tailor their learning experience in the fifth semester with elective courses chosen to delve deeper into specific geomatics subfields that align with their interests and career aspirations. For example, the Geomatics Project Work course offers a dynamic and project-based experience for the individual student. Two things set this Geomatics Project Work course apart from the student's previous learning experiences, flexibility and off-campus collaboration. The flexibility stems from crafting a project on a student-by-student basis, and collaboration with industry experts or public institutions to bring real-world context to the projects. This individual student project can extend beyond the semester and serve as the foundation for a bachelor's thesis guided by faculty members to oversee project planning, advancement of topic-specific knowledge and insight, and skills in structuring and presenting their findings. The thesis also showcases the student's skills to potential employers and provides valuable insights into industry practices, preparing for a successful transfer from student to geomatics professional. Additionally, during the 5th semester, organized exchange programs offer international experiences, enabling students to gain a global perspective for geomatics and allows students to specialize in areas not typically offered in the Geomatics program at NTNU Gjøvik (i.e., remote sensing).

Table 3: Learning outcomes for courses offered in each part of the geomatics-engineering program

	1st year: 1-3 semesters	**2nd & 3rd years: 4-6 semesters**
Learning outcomes	Develop a foundational understanding of the engineering profession and basic knowledge in geomatics, mathematics, physics, and programming.	Specialize in specific areas of geomatics, such as geographical infrastructure, terrain modelling, and geographic data acquisition.
	Gain proficiency in the use of geomatics instruments and technologies for accurate measurements and calculations.	Gain practical experience and skills through the completion of a bachelor's thesis project.
	Learn to handle, store, present, and analyze geographic data for various purposes.	Develop expertise in a particular area of interest within geomatics.
Skills Development	Proficiency in using instruments and technologies such as satellite technology, drones, laser scanning, and land surveying instruments.	Advanced knowledge and skills in specialized areas of geomatics, depending on the chosen elective courses and bachelor's thesis topic.
	Data handling, storage, presentation, and analysis skills for geographic data.	Project management and research skills through the completion of a bachelor's thesis.
	Mathematics, physics, and programming skills applicable to geomatics engineering.	Collaboration and communication skills through working with external organizations or companies for the thesis project.
	Problem-solving and analytical skills.	

Table 3 outlines the learning outcomes and skills development that represent the comprehensive character of the Geomatics education. These outcomes point to technical competencies (Table 2) as well as the development of critical thinking, problem-solving abilities, and effective communication skills. For example, the learning objectives for the first-year students focus on foundational language and concepts, use of technology and the organization of geographic data. Students build on this knowledge and experiences in the second year with professional specialization subjects in geomatics (i.e., geographic infrastructure and information processing, terrain models, geographic data capture and basic networks). The final year (3rd year) offers various elective options for further specialization, project work and exchange programs or study abroad. In the final semester, students focus on project development and completion, collaboration with industry or organizations, and professional communication (i.e., report writing) and networking. The clarity of outcomes serves to provide a roadmap for students to achieve proficiencies in geomatics through applied knowledge and skills development in land surveying and geographic information systems (GIS).

2.1 Current Strengths of the Program

In addition to the structure of the Geomatics program being professionally regulated and stipulated, the needs of industry and government are embedded into the program. This is facilitated through principles of the CDIO formulating what engineers should learn for technical knowledge and reasoning. For example, students gain experience with advanced technologies (i.e., LiDAR, satellite data, drones, etc.), preparing them for the demands of the industry or government. The strength of the NTNU Gjøvik Geomatics program is the exposure of students to practical applications, interdisciplinary problem solving, cutting-edge technology, geospatial data analysis, professional development, and an international perspective. The program emphasizes hands-on learning experiences, including short-term fieldwork, data collection, and the use of advanced technology and instruments. This practical approach allows students to apply theoretical concepts to real-world scenarios, developing valuable skills and competencies.

The scientific interdisciplinary nature stems from courses taken in engineering, mathematics, geospatial sciences, computer science, etc. This multi-disciplinary approach enables students to develop a broad skill set and scientific understanding of geospatial data collection, analysis, and management. The Geomatics program emphasizes the analysis and interpretation of spatial data for various applications, including urban planning, environmental management, infrastructure development, and disaster management. Students develop skills in data processing, visualization, and spatial analysis, which are highly valuable in today's data-driven world.

Professional opportunities for geomatics graduates include strong job prospects due to the increasing demand for professionals with geospatial skills 95% of all candidates from NTNU obtained full-time employment within 1 year of graduation (Kandidatundersøkelsen 2022). The geomatics field offers diverse career paths in sectors such as surveying, mapping, GIS analysis, remote sensing, geospatial data management, and consulting. The individual students from the Geomatics Project Work course are in demand because of their previous collaboration with industry partners, government agencies, and research institutions.

2.2 Critical Review

Some potential areas that could be considered for improvement include extended field experience, responding to industrial needs and soft skills development. While many NTNU Geomatics courses include practical components, such as fieldwork and data collection, these tend to be short-term experiences (i.e., a couple of hours, an afternoon). There is currently no course that addresses more extensive and diverse field experience which would better reflect employment scenarios (i.e., multidisciplinary teams that include non-science members, working on a single project for weeks or months, addressing all aspects from design to implementation, etc.). Increasing the emphasis on longer-term field training, teamwork and project life cycle would better prepare students for the challenges they may encounter in real-world geospatial projects. In addition, although there are several exchanges and study abroad opportunities, few NTNU Gjøvik students participate in these options, and as a result, they are not gaining a global perspective on geospatial issues in cross-cultural environments.

The Geomatics program could also further enhance its collaboration with industry partners to ensure that the curriculum aligns with the future needs and trends of the geospatial industry. For example, although NTNU Gjøvik geomatics program excels in technical knowledge and reasoning, personal and professional skills and attributes, the other CDIO principles of teamwork and communication, and systems understanding in the enterprise and societal context could be improved. The further development of ‘soft skills’ is of equal importance to scientific and technological skills. Increasing opportunities for students to develop these skills through participation in team projects, network building and enhancement of overall competencies is needed.

3 REFLECTING ON COLLABORATIVE RESIDENTIAL FIELD COURSE IN CHURCHILL AND RAUBERGSTULEN

Through field course experiences with UWinnipeg, NTNU faculty observed the significant value of the experiential learning/field courses that could be used to improve the Geomatics program. The collaboration between NTNU Gjøvik and UWinnipeg started in 2016 with a High North Programme award “Sustainable energy system design, evaluation and governance” (HNP-2016/10024). A two-week residential field course was held in Churchill, Manitoba (Canada) in August 2018 to meet the education deliverable of this award to support joint education, student mobility, and increased quality and internationalization of study programs in Norway (Norwegian Directorate for Higher Education and Skills, 2020). UWinnipeg geography faculty have offered many field courses in Churchill and abroad (e.g., Mexico, California, Argentina) with an integrated approach to address human and physical geography as well as geomatics in activities and project-based learning. Fifteen undergraduate students from NTNU Gjovik and UWinnipeg participated in the course with faculty expertise in human/cultural geography, physical geography, geomatics, and civil engineering. During the course, some of the students participated in a project that benefited the community through precise surveying and mapping of the Churchill Complex envelope (i.e., one building with the hospital, schools, community centre, bowling alley, etc.) to calculate interior volume energy requirements. This course also resulted in a collaborative publication, led by a student, on the evaluation of the Arctic Spatial Data Infrastructure global collaboration (Burroughs et al., 2019).

Reflection of this initial collaborative field course included lessons on education focus, Canada-Norway course offerings, and student expectations. A decision was made to continue collaboration with UWinnipeg faculty specializing in geomatics skills development, knowledge applications and competencies relevant to NTNU civil engineering students. The faculty recognized that common goals and effective communication in cross-cultural and multi-disciplinary settings could only be achieved through the willingness of those faculty members to put in the extra effort to address time zone differences as well as variability in funding and academic schedules (Burroughs et al., 2019). For example, it is not unusual for Canadian students to pay for the field course expenses and participate in courses outside the normal fall-winter offerings. Norwegian academic culture differs from Canada in that faculty and students would not be expected to participate outside of normal course offerings and students would not pay for this field experience.

Table 4: Examples of residential field courses offered in civil engineering programs

University	Year	Field Course Focus
Imperial College London	1	Residential Surveying camp
University of Bath	1	Residential field trip for geology, hydrology and surveying
BCIT (Canada)	1	Prospecting and exploration field school
Cardiff University	2	Field Studies of the Natural and Built Environment
Imperial Collect London	2	Geology or Construction
University of Edinburgh	3	Residential Surveying Field Trip
Ajayi Crowther University, Oyo (Nigeria)	3 & 4	Residential field courses Field Studies of Natural and Built Environment
University of Concordia (Canada)	4	International development and global engineering
Idaho State University	4	Field Geology (5 weeks)

As a result of further funding, primarily from a Norway award for “Map production using advanced techniques in neural networks and remote sensing (PNA-2019/10090)” but also from UWinnipeg Experiential Learning award “Norway Field Course in Geomatics (EL-2022/60394)”, a second field course was offered in Raubergstulen, Oppland in August 2022. Like the first field course, it was designed to be project-based, student-centred learning with abbreviated but meaningful lectures; however, this course was focused solely on geomatics projects. Lectures and excursions on remote sensing, surveying, neural networks for map automation, drones, glacier dynamics, precision agriculture, climate change, and geology was delivered by NTNU and UWinnipeg faculty, and professionals from the NIBIO centre for precision agriculture (Apelsvoll, Ostre Toten), Klimatpark 2469, and Helvete (Espendalen). The Raubergstulen course was unique compared to the Churchill field course as it included graduate students. The graduate student role was to identify projects and design field sampling methods to be completed by the undergraduate students in the course. The long-term, international residential field school provided opportunities for technical, scientific and soft-skills development in team environments. This is a type of course format lacking in the existing NTNU geomatic course offerings, and the field course offered an effective format to rapidly achieve competencies in multi-disciplinary, complex problem-solving.

There is precedent for residential field schools within civil engineering programs (Table 4) focused on surveying, natural or built environments, and geology. NTNU Gjøvik faculty often engage their geomatics students in site visits and outside-classroom experiences on campus. However, the extended residential field course format brought students to new ecological environments, has longer time commitment to projects, and includes students from other disciplines/cultures, all of which better prepare these students for future working environments. The incorporation of the master's students into the field course also provided undergraduate students with exposure to the graduate school research process and a potential future path often not considered before this experience. Project participation included community-based activities to quantify the value of synthetic materials to reduce snow melt on a ski hill, field validation of a map produced using a neural network model, scalable information from ground to drone to satellite, and estimating glacier edges using infrared imagery.

4 IDEAL NTNU GEOMATICS FIELD COURSE?

Residential field courses are effective pedagogical formats to increase students' preparedness for future challenges (Gosen and Washbush., 2004; Klakegg et al., 2019). These courses meet the need to "*refine teaching and learning strategies to improve student competencies in understanding, assessing, and taking action*" on problems that are more complex in nature (Koran and Baker, 1979; Kricsfalusy et al., 2016). Modern day problems are complex as they require civil engineering professionals to increase their social and environmental responsibility for infrastructure adapted to natural disasters, population growth, and climate change. (Tougwa, 2020). Pedagogical literature about field course learning objectives, outcomes, and methods will focus on the diverse activities and learning environments that address 'real' problems (Gold et al., 1991; Warburton et al., 1997; Storie and Bugden-Storie, 2010; Easton and Gilburn, 2011). However, of equal importance, these projects are conducted in the same manner as the students would experience in their future employment (i.e., rapid solutions and implementation, teamwork, science and non-science interactions, international perspective, etc.).

In order for field courses to be adopted and valued within a program and by administrators, the faculty must articulate how these courses enhance students' opportunities and offer a significant benefit to the community and industry partners (Pyle, 2009). The first step in this process was the recognition there was a need for a residential field school within the Geomatics program at NTNU Gjøvik (Figure 1). In addition, there is currently no geomatics field course offered Norway, and this proposed course is invaluable for the rapid/condensed learning experience to reflect employment experiences.

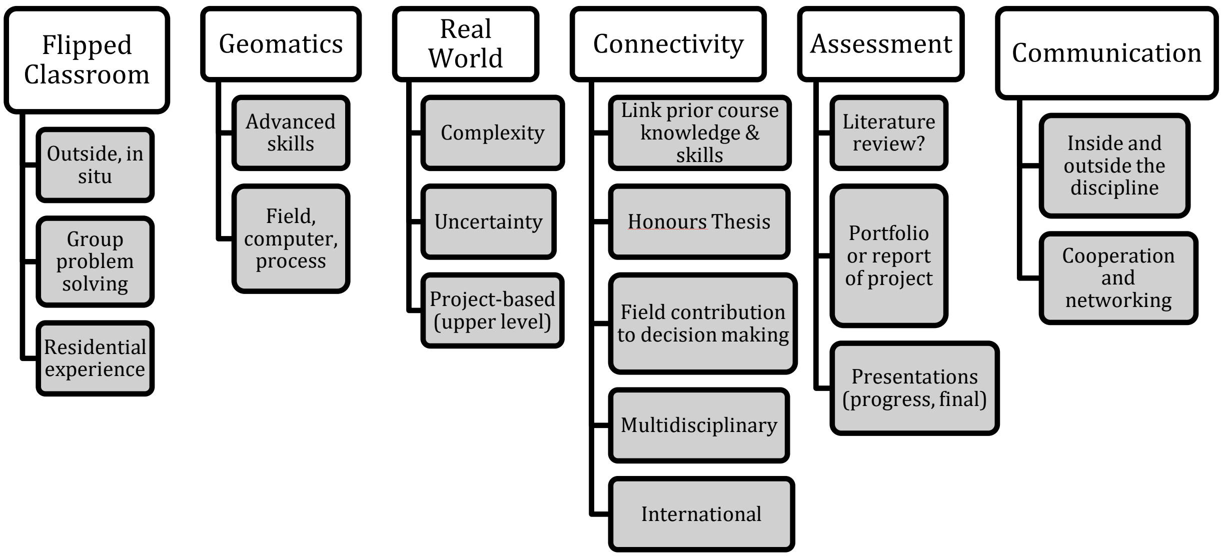

Fig. 1. Key principles for NTNU Civil Engineering "Geomatics Field Work" course

Based on experience in both field courses (Churchill, Raubergstulen), it is suggested that the ideal Geomatics Field Course be offered during the last two weeks of August. Other disciplines in Norway offer field experiences during August (i.e., geology) as the field data collected in late summer can be accomplished with adequate preparation in the spring semester and subsequent documentation and report writing in the fall semester.

This course would occur between the second and third year of study and as such, build upon the knowledge, skills and competencies already developed (Table 3). Learning outcomes of the Geomatics Field Course would include project management, extended and full project experience from framing a research question to analysing and communicating those results. The Geomatics Project Work course also provides the individual student with the foundations for participating in a Geomatics Field Course due to the student's individual project experience. There would be a focus on soft skills such as written and oral communication, teamwork, project management, and complex problem-solving over the life-cycle of a project (Kricsfalusy et al., 2016; Tougwa, 2020).

Based on experience, a course duration of 10 to 12 days is ideal for a residential field course; this time period works well as a result of long days and the intensity of the learning experience. Students and faculty would travel to a non-campus location for the residential field course. During the day, students usually collect data while the afternoons and evenings are used for organization and processing data, brief lectures for the next day's activities, or informal team presentations of project progress. The field course should be conducted in a remote location with a good internet connection and with a suitable area of work for processing data and joint presentations. In addition, there should be facilities for gathering and socialisation, as well as quiet spaces for solitude and recharging.

Assessment of technical skills would depend on faculty expertise; thus, it could include fieldwork logistics, surveying techniques in remote areas, static GNSS measurements, UAS data acquisition, and terrestrial laser scanning. Criteria for assessment could include a literature review of methods in the spring prior to the field course (Figure 1). During the Geomatics Field Course in August, students might be assessed on their leadership of field method instruction for a particular day, informal progress reporting, or their efforts to be collaborative, show initiative or to network with other students, Norwegian and international. Finally, in the fall term, the assessment would include the completion of a research paper that would follow a discipline-specific format and a final presentation of methods and results at an end-of-term colloquium.

Ideally, offering field courses with another international academic institution appears to be more appealing to Norwegian students than traditional exchange programs for individuals. Whether it is hosted in Norway or in an international setting, the Geomatics Field Course would better enable the cohort of students to gain a different perspective of geomatics as a group. Globally, geomatics is offered within various disciplines, such as civil engineering, geography and geology, allowing Norwegian students to participate in multi-disciplinary teams and gain specialization not offered at NTNU Gjøvik. The Rauberstulen and Churchill field courses worked well with students at different levels (bachelor and master) and with different academic backgrounds. This provided the students the opportunity to work across cultures and disciplines, and to contribute their expertise towards a project or particular task.

The NTNU Gjøvik students have many of the practical skills for conducting fieldwork with the training they have experienced from 1st and 2nd years on campus. The Geomatics Field Course will expand upon those experiences through multiple term focus on one project, from literature review of methods to data collection and analysis, to communication of results in written and verbal form. This places far greater demands on the students, especially in the planning and preparation, testing of equipment and measurement methods, to extended collaborative working environments. For most students, this will be a significant and relevant experience that will be very beneficial for later employment situations, completion of an undergraduate thesis or potential engagement in graduate school. These prior experiences promoted a broad perspective on learning outcomes to reflect different disciplines (i.e., geography, civil engineering, computer science), student educational backgrounds (2nd, 4th or graduate levels), operating in varied ecosystems (i.e., alpine, boreal, periglacial, etc.) and in international locations. Students will be encouraged to further develop advance technical and soft skills within collaborative research projects facilitated through curriculum development, international experience, and research.

5 WHAT IS NEXT? HOW TO IMPLEMENT THE COURSES

Field courses are demanding to undertake in Norwegian engineering education, although programs in geoscience make it happen in Oslo and Bergen. There is generally limited opportunity for compulsory summer courses due to regulated and prescribed offerings to meet professional certifications. During the semester, students normally have 4 compulsory courses that are run parallel in autumn and spring. Several of these courses are common courses with other study programmes. In practice, longer stays off campus are challenging to accomplish as they affect the progression in other courses in that term.

As the framework stands, a field course can only be completed as an optional course in the 5th semester with up to 1-week duration. Late August or September is probably the best time, with necessary preparation before the summer. In the current study plan, the optional project course of 7.5 credits in the 5th semester that can be adapted to the optional field course. A compulsory field course in the 5th semester would pose difficulties for those students who choose to study abroad as this is the same term assigned for international exchanges. However, students are more likely to engage in the Geomatics Field Course as a cohort over individual study abroad experiences.

Additional costs for field courses must be included in the operating budget for the department. There is a significant budget allocated for lab space, equipment, and software at NTNU Gjøvik. A similar costing structure could be assigned to the Geomatics Field Course, after consultations with geoscience programs in Oslo and Bergen. Finally, geomatics faculty contributing their time to the Geomatics Field Course is beyond the 9-5 workday for which they should be compensated. Responsibilities include planning and organizing the residential field course accommodations and logistics, integrating international partner institutions, providing evening lectures, supervising field data collection during the day, provision of first aid, etc. Compensation could take the form of time off with pay in future or monetary reward.

Even with these remaining hurdles, NTNU Gjøvik sees the introduction of the Geomatics Field Course as an essential addition to the Geomatics program. The reflection of the existing program shows the strengths of technical knowledge and reasoning as well as personal and professional skill development. However, participation and reflection of the two field courses held with UWinnipeg in Churchill and Raubergstulen also highlighted the need to further develop teamwork and communication, obtaining a global perspective, and the broader applicability of their education for business and societal benefits. And this can be obtained in an effective and efficient manner through the Geomatics Field Course offering. The aim of the Geomatics Field Course is to improve student competencies, advance skills, improve interdisciplinary literacy, and transition from reductionist to integrative problem-solving. In addition, since field courses are rare in Norwegian engineering programs, this outline also benefits other engineering programs in Norway.

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