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Multidisciplinary Major Design Capstone Projects

Dr. François Michaud, Universite de Sherbrooke

François Michaud, Ph.D., is an engineer and full professor in the Department of Electrical and Computer Engineering at the Université de Sherbrooke, in Québec Canada. He is the founding director of the Bachelor of Robotics Engineering Program (2017 - 2022) at the Université de Sherbrooke, the first and only one in Canada. He is also a co-founder of Robotique FIRST Quebec (2010 -).

Audrey Boucher-Genesse, Universite de Sherbrooke

Audrey Boucher-Genesse is an engineer and a professional at the Faculty of Engineering at the Université de Sherbrooke. She studied in Electrical Engineering (2002-2006), worked in industrial robotics at AV&R, then worked actively at the creation of the Robotics Engineering Program until 2023. She is now involved in Major Capstone Design Projects, which involve 4 Engineering programs.

Prof. Jean-Sébastien Plante, Université de Sherbrooke

Jean-Sébastien Plante, Ph.D., is an engineer and full professor in the Department of Mechanical Engineering at the Université de Sherbrooke, in Québec, Canada. He developed the "makers" culture at Université de Sherbrooke in both teaching and research. Since 2023, he is the Director of the Studio de Création, the fablab fostering the design, fabrication, and test of more than 30 fully functional engineering prototypes each year.

Multidisciplinary Major Capstone Design Projects

Introduction

In our Faculty of Engineering, we define Major Capstone Design Projects (MCDP) as open-ended design projects, from project identification to fully functional prototype fabrication and testing, involving large teams of students, normally from six to eight, and accounting for 12 credits out of 120-credit programs. The Department of Mechanical Engineering (ME) and the Department of Electrical Engineering (EE) and Computer Engineering (CE) have been offering MCDP courses for about 30 years. The scope of the projects in both departments frequently overlapped disciplinary boundaries, and students either had to acquire on their own knowledge and skills missing in their training, or to find ways to collaborate with teams from the other department, which revealed to be difficult.

As a solution, the launch of the Robotics Engineering (RE) program in 2017 provided an opportunity to unify the MCDP courses for all programs. Put in place in the Summer 2020, multidisciplinary MCDP (M-MCDP) consists of three courses distributed over the last three semesters of the ME, EE, CE and RE curricula. M-MCDP involves an open call for project ideas, multidisciplinary assessments of these project ideas by groups of students, three courses over the last three semesters of their undergraduate curricula, multidisciplinary team teaching, and skill-based evaluations. Having the opportunity to combine their expertise with other engineering fields creates for students a real teamwork learning experience that enhances their preparation for their future professional practice. Graduating the fourth M-MCDP cohort in December 2024, the paper presents the benefits and impacts on graduates' engineering career, as well as the limitations and areas for improvements, gathered from surveys of alumni and graduating students. Being involved in large-scale, real, and complete multidisciplinary design projects that they manage independently allows students to develop not only their technical skills but also their project management and professional abilities. The Public Expo also stands out as a significant strength. The main challenges include ensuring uniformity in team teaching, addressing organizational issues in open-ended projects, and managing coordination and training across multiple programs.

Background

Multidisciplinarity in undergraduate engineering design capstone projects has been identified to be important [1,2], even 30 years ago [3], and there are an increasing number of initiatives reported [4,5]. But still, it has not been widely or sustainably practiced in engineering schools [2], and many institutions struggle to create these opportunities within their curricula [1]. Some of the identified obstacles are curricular and knowledge differences across departments, university structure and organization, differences in faculty rewards and expectations [1]. Successful multidisciplinary work takes time, money, support, and people willing to champion not only the initial development but also provide a sustainable structure [1]. We experienced such obstacles when MCDP student teams from two departments were collaborating, because assessment tools, requirements from instructors, schedules, and evaluation criteria differed between departments, making it difficult to promote and support multidisciplinary teaching and learning. We considered having teams from one department being supervised by the other department, but administrative issues made this impossible.

The launch of the Robotics Engineering (RE) program in 2017 provided the opportunity to revisit the MCDP courses. Initially, the plan for the RE program was to adopt the MCDP courses from the ME program, which span over three semesters to give more time for fabrication and assembly of mechanical structures. However, the two targeted professional scenarios of the RE program were directly aligned with the M-MCDP courses, i.e.:

i. Design a robotic system involving the integration of mechanical, electrical and computer components, for a given application context.
ii. Manage multidisciplinary teams for robotic projects.

Additionally, it was decided that the RE program would be managed at the faculty level, bridging the EECE and ME departments, which facilitated the allocation of resources for establishing the new MCDP courses. The aim was to develop a common framework enabling ME, EE, CE, and RE students to effectively work together by combining and managing the disciplinary expertise required to achieve the projects.

The intent with MCDP is to provide students with a real, complex, and comprehensive design experience representative of real professional situations. To move beyond disciplinary boundaries of engineering programs, the aim for M-MCDP was to develop a common framework enabling ME, EE, CE, and RE students to effectively work together by combining and managing the disciplinary expertise required to achieve the project. It also requires to involving a team of instructors to cover the scope of expertise of projects. To ensure consistency, they must follow a set of standardized procedures and requirements for the courses, while also maintaining the flexibility to adapt to the specificities of each project. In most cases, the instructors intervening with a team change over each semester, making it essential to have common practices between instructors. A detailed review of the MDCP course tracks from the ME and EECE departments was conducted, outlining their similarities and the differences [6]. The ME track followed a common, traditional design methodology, while EECE let the teams decide what design methodology to follow. By allowing students from EE or CE to work in the same team, the EECE Department already experimented with having to supervise teams with broad expertise, adding the intervention of specialists to support teams and complement the expertise of the supervising instructor. The EECE Department also adopted in 2001 a problem-based and project-based learning approach [8], changing teaching load assessment based on contact hours which underestimated the workload compared to using group size. A time estimation method was developed for MDCP regarding teaching load, with roles and responsibilities for group teaching.

Overview of M-MCDP

The M-MCDP course focuses on open-ended projects with real clients or well-defined objectives. A detailed description of the M-MCDP activity is provided in [6]. Preparation begins in Semester 5 (S5) with a call for project proposals from various sources: industry, faculty and research labs, student competition design teams, and student entrepreneurship initiatives. During a 1-day activity at the end of S5, students are invited to evaluate project proposals based on criteria like feasibility, impacts, and management. Evaluations, shared via Teams, promote critical thinking and team formation, with revised proposals prepared for S6. The M-MCDP course begins in S6 and spans three semesters (S6–S8):

- S6 (May–August, 3 credits, 1 day/week): Students finalize teams (6 to 8 members) and submit project proposals by Week 2. They then define project scope, requirements, and risks, submitting a 20-page Project Identification Report (PIR) by Week 7. Weekly meetings focus on project management and technical progress, supported by workshops and seminars. Student teams are guided in developing a team contract and a project dashboard framework, which serve as tools for tracking progress during weekly meetings focused on project management discussions and the technical aspects of their work. Student teams have the liberty to choose and experiment with their own project management tools and methods. The semester concludes with a group oral audit, individual technical audits, and a 35-page Project Design Report (PDR) presenting conceptual and preliminary design.
- S7 (January–April, 6 credits, 2 days/week): Focus shifts to the detailed design and assembly, with two weekly meetings (one for project management and one for technical progress), two group oral audits and two individual technical audits (mid-term, end of term), and an 80-page PDR at the end of the semester.
- S8 (September–December, 3 credits, 1 day/week): Testing and validation dominate this phase, again with weekly meetings as in S6, and culminating in one group oral audit, one individual technical audit, a Public Expo presentation, and a 40-page final PDR. Teams must assess risks and create, when necessary, safety protocols with support from lab coordinators and supervisors. These processes are very important in open, large scale design projects to ensure the safety of the students.

Each semester has 15 to 17 weeks, with 135 hours of estimated work for every 3 credits. Being in cooperative training programs, students are doing internships between each semester, making the M-MCDP course track span over 20 months. The M-MCDP courses leverage all 12 Graduate Attributes (GA) in engineering but only six are evaluated using three key competencies:

1. Engineering Development: Students execute projects aligned with design standards, regulations, and sustainability, assessed through GA-4 (Design), GA-9 (Impact on Society and Environment), and GA-12 (Lifelong Learning).
2. Project Management: Students manage projects using processes tailored to engineering practices in ME, EE, CE, and RE, evaluated via GA-11 (Economics and Project Management).
3. Professionalism and Communication: Students demonstrate professionalism and effective communication in project execution, assessed through GA-6 (Teamwork) and GA-7 (Communication Skills).

A team of instructors follows standardized procedures across semesters, supported by an Instructor Guide, training videos, and weekly progress meetings. Each student team has a professional engineer as a supervisor, assisted by specialists (teaching assistants) who provide technical expertise in relation to the project. Instructors' roles are to provide advice, challenge, and support the teams, but not to take responsibility for managing the teams or for the technical works. Typically, the number of supervisors range from 5 to 14 per semester, while specialists range from 11 to 20. In most cases, the instructors working with a team change over each semester, making it essential to maintain consistent practices among instructors. New instructors receive specific training, including video modules, and weekly 1-hour lunch meetings are held to discuss team progress and address uniformity and calibration issues.

Grading is conducted by multiple evaluators, with calibration to ensure consistency. Skill-based grading uses six of the twelve GA from the engineering accreditation board. A criterion-referenced assessment approach is used, with qualitative descriptions provided on a five-level grading scale (0 – Not Addressed 0%; 1 – Insufficient 25%; 2 – Fair 58%; 3 – Good 70%; 4 – Very good 82%; 5 – Excellent 100%). All evaluations use the same standardized evaluation grids, providing a common reference for students and instructors to help ensure calibration and uniformity among graders. These grids are non-specific to deliverables, which is necessary given the diversity and flexibility of the projects (e.g., design methodology, project management). Instructors must adapt to the specific situation of the projects, as each student teams determine on their own when to do what and how they manage their projects. Group oral audits and presentations, as well as individual technical assessments, use an average of individual ratings. When discrepancies greater than one level occur on the five-level scale, a calibration discussion is conducted to validate and align the ratings.

Each semester, evaluations are divided 50-50 between team and individual assessments, with team grades being individually allocated using peer evaluation. Team evaluations include PIR and PDR, assessed by their team supervisors, and group oral audits evaluated by three members of the teaching team (two team supervisors and one specialist). Multi-instructor grading involves averaging individual ratings, with a calibration process in which differences greater than one level on the five-level grading scale require a discussion to validate the ratings. Individual assessments take into consideration all activities conducted during the semester, whether they are taking part in management meetings, technical meetings, audits and presentations. Mid-term formative grading provides feedback on individual performance, allowing students time to make improvements if needed. Students are expected to actively participate in meetings, provide detailed technical explanations, follow a structured design process, and seek advice on issues they may encounter. An individual technical audit consists of a 10-min video presentation summarizing the technical work they should have presented earlier in technical meetings, allowing for individual assessment of their technical contributions to the team. At the end of the semester, an individual Self-Evaluation Report requires students to present a critical analysis of their learning achievements, strengths, and shortcomings in relation to the three competencies outlined above, as well as a self-analysis on the impacts of the project on their work ethics, methodology, and their professional development.

The M-MCDP course track involves over 230 students from four engineering programs. Microsoft Office Suite tools (Teams, OneDrive, SharePoint, Excel) facilitate communication between instructors, management of deliverables, and grading using organized repositories and shared workspaces. A comprehensive 120-page Student Guide gathers all the information for the entire M-MCDP course track. The goal is to centralize everything into a single document, making it easier to keep the documentation up to date. In addition to the Student Guide, students have access to a SharePoint site containing documents and video recording of presentations on a wide variety of topics related to the M-MCDP course track, such as technical design, conflict management, intellectual property, confidentiality, ethics, and client relations. Students also provide feedback via online surveys and end-of-semester meetings to discuss improvements.

A dedicated M-MCDP staff coordinator manages year-round course activities, assists with client relations and intellectual property issues, and supports teams throughout the process. A semester-specific faculty representative, in collaboration with the coordinator, works with departments and faculty officials to ensure smooth operations.

To provide a general overview over the four years of M-MCDP existence, the number of monodisciplinary projects decreased, moving from 45% to 25%, resulting in more multidisciplinary projects [6]. EE-CE projects, which were usual in the previous MCDP activities because they were managed by the same department, also decreased. This trend, also supported by course surveys and reviews with the groups, suggest that having the opportunity of working in multidisciplinary teams is very much appreciated by the students. About 70% of the multidisciplinary teams include RE students, suggesting that the existence of the RE program may facilitate M-MCDP [6], as it helps integrate and manage the disciplinary expertise.

Experimental Method

Now that M-MCDP has been in place for four years, we decided to conduct two online surveys to examine its benefits, impacts, limitations, and areas for improvement:

A. This survey targets graduates from the most recent three cohorts. We used the email lists from their time as students, along with posts on the MS Teams channel, assuming that graduates still have access to these communication platforms. The questions are:
    - A1. Which program were you enrolled in?
    - A2. Which graduating class (cohort) were you part of?
    - A3. Are you currently employed in the field of engineering?
    - A4. What did you appreciate about the M-MCDP courses (open question)?
    - A5. Did the M-MCDP courses have a real impact on your engineering practice (open question)?
    - A6. What improvements could be made to make the courses even more realistic in terms of engineering practice, both technically, in management, and in professionalism (open question)?

B. This survey is for students from the fourth cohort, i.e., graduating students finishing the M-MCDP activity in December 2024. We also used the email list and posted on the MS Team channel during December, i.e., after the Public Expo and before the submission of the final reports. The questions are:
    - B1. Which program are you enrolled in?
    - B2. What is your level of satisfaction with the courses (5 levels)?
    - B3. What is your evaluation of the activities in the course (5 levels, 20 topics)?
    - B4. What are the positive aspects of M-MCDP (open question, with reference possible directly to the 20 topics of question B.4)?
    - B5. What are the negative aspects of M-MCDP (open question, with reference possible directly to the 20 topics of question B.4)?

B6. What are suggestions for improvements (open question, with reference possible directly to the 20 topics of question B.4)?
B7. What types of projects should be prioritized/favored/excluded in M-MCDP?
B8. What was the main motivation in the selection of projects?

Content analysis of the open-ended questions was conducted manually, grouping ideas into either the 20 topics of question B4 or creating more specific categories. The first large-scale evaluation of M-MCDP was conducted in 2021 with the first cohort (n = 74), primarily identifying organizational changes. Improvements were made, and the current objective is to assess how alumni, based on their work experience, perceive the relevance of M-MCDP to engineering practice, and how graduating students evaluate their training experience.

Results and Discussion

Survey A was completed by 101 out of 697 graduates, with the following distribution: 25% ME, 20% EE, 12% CE, and 44% RE; 31% from the 1st cohort, 43% from the 2nd cohort, and 27% from the 3rd cohort. Of the respondents, 75% are employed in engineering, while 25% not (including those who pursued graduate studies).

Table 1 presents a content analysis of the responses to question A4, listed in decreasing order of preference. The opportunity to participate in a large-scale design project that presents a real engineering challenge was identified as the most appreciated aspect. The freedom to select their own team, engage in a multidisciplinary project if desired, and have more autonomy in managing their project were also highly valued. The experience goes beyond technical learning, with project management, teamwork, and financial aspects being particularly appreciated.

For question A5, 83 respondents answered ‘Yes’, 11 answered ‘Moderate’, and 7 answered ‘No’. Table 2 presents a content analysis of the responses provided to question A5, listed in decreasing order of preference. Developing project management skills ranks first, followed by technical skills and teamwork. The realistic nature of the work experience is also noted, suggesting that the M-MCDP activities align well with industry practices. It is also noteworthy that the development of professional skills during the M-MCDP activities was recognized.

Table 3 presents a content analysis of the responses to question A6, listed in decreasing order of preference. Suggestions for organizational improvements must be critically evaluated as they depend on the experience of each team, with each project following its own path. A high-performing team may require less supervision than a team with internal challenges (technical or human-related). Training improvements highlight areas where additional resources and tools can be provided to better support student teams. It is interesting to note that making client involvement and multidisciplinary mandatory has been identified as improvements, suggesting that alumni view these elements as important for making M-MCDP a realistic learning experience. Finally, supervision improvements are noteworthy because managing project scope and expectations is challenging for students due to their lack of experience. It is also difficult for the instructors because they are unfamiliar with the students and do not want to limit their interests and engagement with the project. Also, instructor calibration has been a focus since the beginning with M-MCDP. However, students must also learn to receive feedback and guidance from multiple perspectives, which happens continuously in the practice of engineering, while also developing critical thinking skills. Suggestions include involving industry specialists (which is already implemented) and identify specialists who can provide management expertise, rather than focusing solely on their technical skills.

Table 1. Content analysis of question A4 regarding what students appreciated about the M-MCDP courses.

What did you appreciate about the M-MCDP courses?	No. mentions
Large-scale complete design project	32
Project and team selection	26
Multidisciplinarity	23
Autonomy, self-management	17
Project management learning	12
Real, practical, and complete engineering experience	12
Technical learning	8
Teamwork experience	8
Public Expo	7
Multi-semester activity	6
Tools and support	5
Course organization	4
Time allocated for the activities	4
Budget management experience	3
Specialists in support of the teams	3
Teacher feedback	2
Group oral audit	1

Table 2. Content analysis of question A5 regarding the impact the M-MCDP courses have on engineering practice.

Did the M-MCDP courses have a real impact on your engineering practice?	No. mentions
Project management skills	22
Technical skills	17
Teamwork	13
Work experience	10
Managing expectations and project definition	8
Professional skills (leadership, trust, perseverance, communication, networking, conflict management, startup)	8
Design methodology	7
Multidisciplinarity	7
Autonomy, self-management	6
Team management	6
Time management	6
Budget management	3
Documentation skills	3
Organizational skills	3

Table 3. Content analysis of question A6 regarding improvements to make M-MCDP courses more realistic in terms of engineering practice.

Categories	What improvements could be made to make the courses even more realistic in terms of engineering practice, both technically, in management, and in professionalism?	No. mentions
Organizational	Clearer deliverables and deadlines	8
Organizational	Reduce reporting and meetings	7
Training	Improve human resource management training	6
Supervision	Improve project definition phase with better expectations management	6
Supervision	Provide management tools and management specialists	6
Project Requirement	Establish client involvement as a mandatory requirement	5
Supervision	Ensure uniformity between supervisors	4
Organizational	Improve coordination between ME, EE, CE, and RE	4
Supervision	Provide access to more specialists from industry	4
Training	Provide more project management training	4
Organizational	Support in identifying funding sources	4
Organizational	Add formal design reviews	3
Project Requirement	Broaden multidisciplinarity (Business, Law, other Engineering programs)	3
Training	Add specialized technical training sessions	2
Training	Add test skill training	2
Training	Improve contingency planning training	2
Training	Improve documentation skills	2
Organizational	Improve entrepreneurship support	2
Training	Improve security training	2
Training	Provide more examples from industry	2
Organizational	Reduce management tasks	2
Organizational	Conduct surprise audits	1
Organizational	Decrease team size	1
Training	Improve CAD skill training	1
Organizational	Improve peer evaluation	1
Organizational	Improve intellectual property management	1
Training	Improve team organization training	1
Training	Improve time management training	1
Organizational	Inform students about the project proposal process sooner	1
Project Requirement	Make multidisciplinarity mandatory	1
Organizational	Provide more flexibility for virtual/onsite meetings	1

Survey B was completed by 113 out of 233 graduating students, with the following profiles: 41% ME, 21% EE, 20% CE, and 18% RE.

Table 4 presents the appreciation levels (1 – Dissatisfied, 2 – Rather Dissatisfied, 3 – Neutral, 4 – Good, 5 – Excellent) related to questions B.2 and B.3. Students seem to appreciate Semester 6 slightly less, as it involves significant work: teams organizing themselves, defining the project, starting the design, and learning and applying the M-MCDP methodology, which is used throughout the following three semesters. While students would prefer to start designing right away, they later come to understand the importance of this initial phase. The overall level of appreciation is good, with EE and CE experiencing slightly more issues mostly related to coordination between programs. In terms of specific activities, Table 4 also provides the list of the 20 topics in decreasing order of appreciation. The ranks from the 2021 survey 2021 and the current survey are presented in parentheses. The Public Expo [7] is consistently a major success, year after year. It is the second largest public event organized by our university, after the graduation ceremony, attracting 12,500 in 2024. Over two days, student teams from eight engineering programs present their MCDP projects to the public. Students are proud and excited to showcase their work. Team size, multidisciplinary composition, project selection, and team formation are also well appreciated. However, students face more challenges with documentation, forms, agreements, and safety protocols, i.e., issues related to logistics and procedures. Each team must assess risks and develop safety protocols when necessary, with guidance from lab coordinators and supervisors. Safety protocols are crucial in ensuring that students take the necessary precautions when testing their designs. However, this activity is the least appreciated by students. Despite frequent reminders about the importance of starting early, students often wait until the last minute to create safety protocols. Significant progress has been made in streamlining and simplifying the process, but evaluation and authorization of these safety protocols still take time, requiring student teams to manage this process effectively.

Table 5 presents a content analysis of the answers to questions B4 and B5, ordered by the differential between positive (+) and negative (-) aspects. The topics are taken from the list in question B3, with additional topics identified from the responses. As in Table 4, the Public Expo is identified as a positive element, along with supervisors, the possibility of having multidisciplinary teams, and the coordination and organization of M-MCDP activities. Students consider these elements to provide a real, practical, and complete engineering experience. Consistent with Table 3, the uniformity between supervisors is emphasized. Students prefer to avoid receiving conflicting feedback or advice from instructors during the activities or within a semester. Although we do not purposefully encourage such situations, they present a valuable opportunity to develop critical thinking. Students are invited to reach out to the M-MCDP coordination office when facing difficulties in reconciling conflicting requests. Additionally, suggestions for simplifying the safety protocol process, weekly meetings, documentation, and workload are also mentioned.

Table 6 presents a content analysis of the answers to question B6, ordered by the frequency of occurrences. Topics in bold also appear in Table 3. Most of the suggestions are organizational improvements, with a focus on being more specific with deliverables and evaluation criteria. Uniformity between supervisors is once again highlighted, with suggestions to provide more specific guidelines for supervisors and graders, and even allowing student teams to select their own supervisor (though this is not possible). Our safety protocol process has evolved over the past four years, undergoing a series of changes aimed at adapting practices from the two departments. The establishment of a faculty-managed fab lab also introduced new opportunities and processes. After testing new improvements and methods each semester, we have now converged on a common tool and evaluation process. While this process can still be improved, it has resulted in faster response times and better coordination.

Table 4. Appreciation levels for the M-MCDP courses by semester (question B2) and in relation to 20 specific topics (question B3) (1 – Dissatisfied, 5 – Excellent).

Activities	Global	ME	EE	CE	RE
Semester 6	3.5	3.6	3.1	3.3	3.7
Semester 7	3.9	4.1	3.4	3.6	4.2
Semester 8	3.8	4.0	3.5	3.4	4.2
s) Public Expo (#1 → #1)	4.5	4.6	4.2	4.4	4.7
b) Number of students in teams (#3 → #2)	4.1	4.0	4.2	4.1	4.5
c) Multidisciplinary teams (#2 → #3)	4.0	3.9	3.8	4.2	4.2
a) Project selection and team formation (#9 → #4)	3.9	4.0	3.8	3.5	4.2
o) Supervisors (#5 → #5)	3.9	4.1	3.7	3.6	4.0
m) Peer evaluation (#4 → #6)	3.7	3.5	3.8	3.9	3.7
k) Group oral audits (#8 → #7)	3.7	3.9	3.3	3.4	3.9
q) Laboratories and facilities (#6 → #8)	3.6	3.3	3.6	3.8	4.2
h) Weekly management meetings (#11 → #9)	3.6	3.7	3.5	3.7	3.6
e) Start of the semesters (#12 → #10)	3.6	3.8	3.4	3.2	3.8
p) Specialists (#16 → #11)	3.5	3.5	3.5	3.3	4.0
n) Evaluation methods (#13 → #12)	3.5	3.8	3.1	3.5	3.6
t) Workload (#19 → #14)	3.5	3.8	3.2	3.0	4.0
d) Coordination and organization of activities (#7 → #14)	3.5	3.6	3.2	3.2	3.8
l) Written reports (#15 → #16)	3.4	3.6	3.0	3.1	3.8
i) Weekly technical meetings (#18 → #16)	3.4	3.4	3.3	3.1	3.8
j) Individual technical audits (#10 → #18)	3.3	3.8	2.8	2.8	3.7
f) Documentation (#17 → #18)	3.2	3.1	2.9	3.1	3.6
g) Forms and agreements (#14 → #19)	3.1	3.0	3.1	3.0	3.4
r) Safety protocols (#20 → #20)	2.7	2.5	2.5	3.1	3.1

Table 5. Content analysis of questions B4 and B5 regarding positive and negative aspects of M-MCDP courses.

Topics	Global +	Global -	Global Differential	ME +	ME -	EE +	EE -	CE +	CE -	RE +	RE -
s) Public Expo	20	1	19	7	0	4	1	6	0	3	0
o) Supervisors	15	4	11	11	1	3	1	0	1	1	1
c) Multidisciplinary teams	7	0	7	4	0	2	0	1	0	0	0
d) Coordination and organization of activities	7	0	7	3	0	1	0	2	0	1	0
Real, practical, and complete engineering experience	7	0	7	2	0	1	0	2	0	2	0
Flexibility (meetings, deadlines)	5	0	5	4	0	0	0	1	0	0	0
a) Project selection and team formation	6	4	2	3	3	1	1	0	0	2	0
p) Specialists	8	6	2	3	2	3	2	0	2	2	0
g) Forms and agreements	1	3	-2	0	1	0	1	1	0	0	1
b) Number of students in teams	1	2	-1	1	1	0	0	0	0	0	1
k) Group oral audits	3	4	-1	1	1	1	1	0	1	1	1
e) Start of the semesters	1	3	-2	0	0	0	1	0	1	1	1
l) Written reports	1	3	-2	0	2	0	0	0	0	1	1
n) Evaluation methods	0	2	-2	0	0	0	1	0	0	0	1
q) Laboratories and facilities	6	8	-2	2	7	1	1	0	0	3	0
Conflict management support	0	2	-2	0	0	0	1	0	1	0	0
h) Weekly management meetings	2	5	-3	1	3	1	1	0	0	0	1
j) Individual technical audits	3	6	-3	0	2	1	3	0	0	2	1
m) Peer evaluation	2	7	-5	0	5	2	2	0	0	0	0
t) Workload	1	6	-5	0	2	0	3	0	1	1	0
f) Documentation	4	10	-6	3	3	0	3	0	2	1	2
i) Weekly technical meetings	0	9	-9	0	5	0	4	0	0	0	0
r) Safety protocols	1	10	-9	0	6	0	2	1	0	0	2
Uniformity between supervisors	0	14	-14	0	5	0	2	0	6	0	1

Table 6. Content analysis of questions B6 regarding suggestions for improvements.

Categories	What are suggestions for improvements?	No. mentions
Supervision	**Ensure uniformity between supervisors**	8
Organizational	Improve coordination between stakeholders for the safety protocols	7
Organizational	Use specific evaluation grid per semester (especially for group oral audit)	7
Organizational	**Reduce reporting and meetings**	6
Organizational	Use ony Teams or only Moodle for communication (documents, messages)	6
Organizational	**Improve coordination between ME, EE, CE, and RE programs**	5
Organizational	**Clearer deliverables and deadlines**	4
Organizational	**Improve peer evaluation**	3
Organizational	Adapt group oral audits and deliverable requirements to team size and multidisciplinarity	3
Organizational	Improve the dismantling process of the Public Expo	3
Organizational	Improve individual technical audit	3
Project Requirement	Establish client involvement as a mandatory requirement	2
Training	**Improve team organization training**	2
Organizational	Improve laboratories and facilities	2
Organizational	Improve prize distribution for the Public Expo	2
Organizational	Improve specialist range of expertise and training	2
Supervision	Allow the teams to select their supervisors	2
Supervision	**Improve project definition phase with better expectations management**	1
Training	**Improve time management training**	1
Training	**Add specialized disciplinary design training**	1
Organizational	Improve technical meetings	1
Training	Provide examples of issues in budget management and funding	1
Training	Improve conflict management support	1
Organizational	Increase the time for technical meetings	1
Organizational	Make specialists should attend meetings onsite	1
Organizational	Improve project selection	1
Organizational	Impose a format for project management and dashboard	1

Finally, regarding question B7 about the types of projects that should be prioritized, favored, or excluded in M-MCDP, no clear preference emerged from the answers: social impact, entrepreneurship, personal ideas, external clients, research projects, and engineering competitions were all considered acceptable options. Table 7 presents the results of question B8 regarding the main motivation for project selection. The engineering challenge was ranked highest, while simplicity of the project revealed to not be a priority for students. M-MCDP is perceived by the students to take on a significant and interesting engineering challenge.

Table 7. Content analysis of questions B8 regarding the main motivation in the selection of projects (1 – Excluded, 2 – Neutral, 3 – Prioritized).

What is the main motivation in the selection of projects?	Global	ME	EE	CE	RE
Engineering challenge	2.9	2.9	2.9	3.0	2.9
Develop new technical skills	2.7	2.7	2.7	2.7	2.7
Team composition	2.6	2.6	2.7	2.4	2.7
Social impact of the project	2.3	2.4	2.2	2.3	2.4
Multidisciplinarity	2.3	2.3	2.3	2.3	2.3
Simplicity of the project	1.7	1.7	1.8	1.8	1.8

Conclusion

Results from the surveys confirm the importance of multidisciplinarity in capstone design projects. The survey administered to alumni suggest that M-MCDP represents a realistic training experience in the practice of engineering, as intended, with multidisciplinarity as an important component. M-MCDP fosters a real and constructive training environment and offers a teamwork-based learning experience that enhances students' preparation for their future professional careers. Additionally, it serves as a catalyst for cross-disciplinary collaboration and innovation among engineering disciplines. Students value being involved in large-scale, real, complete, and multidisciplinary design projects that they manage independently. Presenting their designs at the Public Expo is highly appreciated, and the event serves as a great showcase of the engineering programs, providing a meaningful and memorable conclusion to the training.

The surveys also highlight the challenges and obstacles in implementing such activities [1,2], as outlined in the Background section. M-MCDP activities present organizational challenges, but these are manageable and the results suggest that both alumni and students find the training experience valuable. These activities require the support of a team of staff members from the department, faculty, and university services (e.g., insurance, intellectual property), with new cases arising each semester. Finding the right balance between consistency across projects and instructors, and adaptability to open-ended projects and self-managed student teams, is essential. Effective communication is crucial in project management [10,11], and this principle directly applies to M-MCDP. It involves coordinating a broad range of student teams across four engineering programs, all supervised and supported by instructors with diverse backgrounds, skills, and expertise. Discussions are currently underway to involve students from our other engineering programs (e.g., biomedical, building). Since communication must flow both ways, the information gathered from the surveys will help us identify areas for improvement in the activities, enhancing coordination and aligning resources across departments and faculty. This paper will be included in the M-MCDP documentation provided to students and instructors, and is an integral part of our continuous improvement process. We will continue our effort to improve uniformity, coordination, and calibration between instructors and staff. Instructors have been administered to the graduating students will also be Additionally, we are continuously adjusting the SharePoint tools used to facilitate document access, clarify deadlines and deliverables, and streamline safety protocol evaluations. We also plan to revise the criteria for peer evaluation and individual implication in the project to clarify expectations and facilitate assessment.

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References

[1] J. Baughman, G. Mosher, A. Gansemer-Topf, and T. Dhadphale, “Feasibility of developing a sustainable multidisciplinary senior capstone experience,” in ASEE Annual Conference &

Exposition Proceedings, New Orleans, Louisiana: ASEE Conferences, Jun. 2016, p. 26897. doi: 10.18260/p.26897.
[2] J.-W. Su, Z. Nie, J. Wang, and Y. Lin, "Lessons learned from multidisciplinary senior capstone design projects," in ASEE Annual Conference & Exposition Proceedings, New Orleans, Louisiana: ASEE Conferences, Jun. 2016, p. 25553. doi: 10.18260/p.25553.
[3] R. L. Miller and B. M. Olds, "A model curriculum for a capstone course in multidisciplinary engineering design," Journal of Engineering Education, vol. 83, no. 4, pp. 311–316, Oct. 1994, doi: 10.1002/j.2168-9830.1994.tb00124.x.
[4] A. Qattawi, A. Alafaghani, M. A. Ablat, and M. S. Jaman, "A multidisciplinary engineering capstone design course: A case study for design-based approach," International Journal of Mechanical Engineering Education, vol. 49, no. 3, pp. 223–241, Jul. 2021, doi: 10.1177/0306419019882622.
[5] A. W. Setiawan, W. Adiprawita, S. Mihradi, I. Herman, A. Handavani, A. Aridarma et al., "Multidisciplinary capstone design project: Biomedical engineering, mechanical engineering, engineering management and product design," in 32nd Annual Conference of the European Association for Education in Electrical and Information Engineering, Eindhoven, Netherlands: IEEE, Jun. 2023, pp. 1–5. doi: 10.23919/EAEEIE55804.2023.10181963.
[6] F. Michaud, J.-S. Plante, A. Boucher-Genesse, A. Bourget, "Major design capstone projects: A multidisciplinary teaching and learning approach," Conf. Proc. Canadian Engineering Education Association, 2024.
[7] Faculty of Engineering, Université de Sherbrooke. "Expo MégaGÉNIALE." https://www.megageniale.usherbrooke.ca (accessed Jan. 19, 2024).
[8] G. Lachiver, D. Dalle, N. Boutin, A. Clavet, F. Michaud, and J.-M. Dirand, "Competency- and project-based programs in Electrical and Computer Engineering at the Université de Sherbrooke", *IEEE Canadian Review*, 41: 21-24, 2002.
[9] S. Rajkumar, "Art of communication in project management," in PMI Research Conference: Defining the Future of Project Management, Washington, DC, 2010.
[10] Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK guide) (7th ed.), Project Management Institute, 2021.