



Development of a Project Management Structure for final year engineering projects in a fast growing university.

Completed by

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North-West University Potchefstroom Campus

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Overview of Document

This report presents the Dissertation for a Masters Research Project that is currently underway at the North-West University at the Potchefstroom Campus. The title of the Dissertation is: Development of a Project Management Structure for final year engineering projects in a fast growing university.

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Duration of study January 2013 – November 2015

Declaration

I, Marzahn Rheeder hereby declare that the content of the Masters Dissertation for “The development of a Project Management Structure for final year engineering projects in a fast growing university.” is my own original work and all references have been listed.



Marzahn Rheeder

10 November 2015

Date

Keywords

Final year engineering project, project application, project selection process, project initiation, project monitoring, project evaluation, project management framework, project management structure, project lifecycle, fast growing universities.

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Definitions

Keyword	Definition
Final year's Project	Engineering project completed by student in last year of study. Final year's Project is also referred to as a Capstone project or senior design project.
Project	Final year's Project
INGM 479	Code for final year's project at the North-West University at the school for Mechanical and Nuclear Engineering.
Project Advisor	Academic advisor for students undertaking final year's projects. Also referred to as faculty advisor. A project advisor is generally a lecturer at the relevant Academic institution.
Research group	Primary focus research subjects in a department in an academic institution.
Sponsor liaison	Liaison between the industry sponsor and the relevant academic final years project personnel.
Comprehensive exams	Simulating the morning and afternoon portions of the fundamentals of engineering examination.
Module Credits	Credit: Value assigned to a given number of notional hours of learning - one credit equals 10 notional learning hours; 120 credits approximate one year of full-time study (Van Wyk, 2009)

Abbreviations and Acronyms

Abbreviations and Acronyms	Definition
ECSA	Engineering Council of South Africa
NWU	North-West University, South Africa
ABET	Accreditation Board for Engineering and Technology, USA
WBS	Work Breakdown Structure
INGM 479	Code for final year's project at the North-West University at the school for Mechanical and Nuclear Engineering.
SOW	Statement Of Work

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Equations

$$avg = \frac{x_2 + x_1}{2}$$

Equation 1

$$avg \text{ number of hours per milestone} = \frac{\text{Project planning} + M1 + M2 + M3 + M4 + M5}{6}$$

Equation 2

$$avg \text{ hours per week} = \text{Number of Students} \times avg \text{ hours per milestone}$$

Equation 3

$$avg \text{ hours per Project leader} = \frac{\text{average hours per week}}{\text{number of Project leader}}$$

Equation 4

$$avg \text{ hours per day} = \frac{avg \text{ hours per Project leader}}{\text{number of workdays}}$$

Equation 5

$$ave \text{ reading speed} = \frac{\text{Average number of hours reading Report}}{\text{Average number of pages for Report}}$$

Equation 6

$$\text{number of hours available} = \text{Hours in year} - (\text{work hours in a week} \times \text{weeks in year})$$

Equation 7

Hours in year = number of work hours in one year.

Work hours in a week = number of available work hours in one week.

Weeks in year = number of work weeks in one year.

$$\text{number of students per Project leader} = \frac{\text{number of students}}{\text{number of Project leaders}}$$

Equation 8

Number of students = number of registered fourth-year Mechanical and Nuclear Engineering students from 2010 till 2019.

$$\text{hours available per year} = \frac{\text{number of hours available}}{\text{number of students}}$$

Equation 9

$$\text{hours available per week} = \frac{\text{hours available per year}}{\text{number of work hours in a week}}$$

Equation 10

Number of work hours in a week = for five workdays in a week with 8 work hours in a day, thus 40 hours in a week.

$$\text{Gradient} = \frac{Y_2 - Y_1}{X_2 - X_1}$$

Equation 11

Abstract

With the increasing number of registrations for final year engineering students at the North West University, Potchefstroom campus, the current final year project structure is not adequate. This current structure results in strain on Project advisors and students.

Research was done to determine the time constraints with regards to lecturers who also act as project advisors. This research concluded that with the increasing number of registrations for final year engineering students, project advisors will not be able to maintain the current workload with the time constraints.

Research was also done on each element of the current structure of final year engineering projects at the North West University, Potchefstroom campus, and also on alternative structures. Comparison between the different structures at different universities concluded that group projects and industry projects prove to be beneficial for departments and students. It also concluded that final year projects must comply with the research programs that are offered by the universities.

One main problem that the research indicated was that students are experiencing problems with writing formal reports which then also contributes to additional strain on project advisors.

From the research a final project management structure, project management framework and a project procedure was developed. The final management structure is a combination of the Programmatic based management structure and the Matrix based management structure. The project management framework that was developed compels projects to be focused and that the ultimate objectives and outcomes of projects are known before projects are initiated. Tools were also developed to aid project advisors and students. One of the tools include aids for students for report writing. This include implementing text editing services and initiating report writing lessons.

1 Introduction and Background

This document contains the methodology for the Masters Research project of Mrs M Rheeder.

According to the NWU, Engineering Faculty, Yearbook of 2013 “The mechanical engineer is involved with the development, design, operation and maintenance of energy transformation systems, transport systems, manufacturing systems and industrial installations. As a result of the emphasis placed on industrial development today, the role of the mechanical engineer is increasing in importance.”

As the role of the mechanical engineer increases in the industry, so does the student registration at the school of Mechanical and Nuclear Engineering. According to Mrs Elza Hatting (2013), (Manager: Recruitment and Student Affairs, at the NWU Engineering Faculty) there is an increase in the fourth year registrations at the school of Mechanical and Nuclear Engineering. The statistical prediction indicates that in six years the number of registered students will increase by an estimated 16% from the current registered number of students.

To obtain a BEng degree at the NWU, a student must pass all of the module-examinations as prescribed in the curriculum. These modules are compiled in such a way that they comply with the exit level outcomes required by ECSA.

In the final year of study, the emphasis of the curriculum is on design and synthesis to fortify the student for the industry. The module INGM 479 Project is designed to provide in this requirement.

INGM 479 Project is a 16 Credit module which incorporates both a theoretical and practical component. This module presents the opportunity for the student to consolidate preceding knowledge obtained (Study guide INGM 479, 2013). However, the infrastructure for the management and implementation of INGM 479 is not applicable to the increasing number of students. Arising problems are occurring and contributing to the adversity of the school.

1.1 Problem Statement

Due to the increasing number of registered final year Mechanical Engineering students at the school of Mechanical and Nuclear Engineering at the NWU, Potchefstroom campus, the current Management structure for INGM 479 is inadequate. Due to this, and with the constrains of available resources, the School is currently struggling with the implementation, organisation and management of INGM 479.

Therefore the problem is to investigate an alternative management structure for engineering final year projects (INGM 479).

1.2 Research Aims and Objectives

The aim of the research is to review current final year's project courses at universities and determine how the problems associated with an increasing number of registrations is addressed. The aim is also to provide a new Management Structure that can effectively implement, organise and manage final year projects with regards to the increasing number of registered students.

The primary objective of the study is to develop and implement a new structure to manage final year engineering projects. This structure should serve as a solution to the students, lecturers and the workshop.

The specific objectives include:

- Management structure for final year projects.
- Tools to aid project leaders (e.g. Text editing services, etc.).
- Tools to aid students (e.g. Templates, writing skills, etc.).

1.3 Expected Outcomes and Deliverables

The expected outcomes and deliverables include:

- An implementable management structure for final year projects.
- An implementable management framework.
- Detailed project procedure.
- Project lifecycle.
- Tools to aid project leaders (Templates).
- Tools to aid students (Templates).

1.4 Limitations to this study

For the methodology the number of final-year project students are not available only the number of registered fourth-year Mechanical Engineering students at the School of Mechanical and Nuclear Engineering at the NWU, Potchefstroom Campus.

1.5 Research Questions

The proposed project is directed by the primary research question:

What is the impact of the increasing number of registered fourth-year mechanical engineering students on INGM 479?

The primary research question can be divided into the following sub-questions:

- What is the impact on the students?
- What is the impact on the lecturers?
- What aids can be implemented?

1.6 Included in this study

Included in research is information based on

- Universities in RSA with ECSA accreditation

Australia	Hong Kong China	Republic of Korea	New Zealand
Canada	Ireland	Malaysia	Singapore
Chinese Taipei	Japan	Russia	Turkey
United Kingdom	United States of America		

- Universities with International Comparability to ECSA and Include universities in:

1.7 Excluded in this study

Excluded in research is information from:

- Technical Universities
- UNISA
- Private Institutions

1.8 Justification of the proposed study

The study was motivated by the desire for a better understanding of course logistics with regards to final year's project. Due to an increasing number of registered students, for engineering programs at the NWU, lecturers, who also act as project advisors, are overloaded. By understanding project logistics and developing a management structure for the organization of final year's projects the workload may be minimized. During the study it was perceived that other academic institutions are also struggling with the same problem.

1.9 Beneficiaries

INGM 479 is a core, 16 credit, module in the Mechanical engineering curriculum at the NWU, Potchefstroom campus. This module certifies that the degree obtained in Mechanical Engineering at the NWU Potchefstroom campus is a bachelor's degree. With the increasing number of registered fourth-year Mechanical engineering students and stationary number of

Project advisors, the management of INGM 479 is becoming problematic. This study will provide a solution and instrument to manage INGM 479.

For the Mechanical and Nuclear Engineering School at the NWU, Potchefstroom campus, this study will aid project advisors to cope with the increasing number of fourth-year registered engineering students, thus allowing the department to be able to expand without any unfavourable results.

For the Engineering faculty at the NWU, Potchefstroom campus, this study can also be adopted by other schools in the department when the management of Project in their schools become problematic due to the increasing number of registered students at the NWU. This study will thus allow the Engineering faculty at the NWU, Potchefstroom campus, to expand without any unfavourable effects in regards to final year's project.

For the NWU, Potchefstroom campus, this study will result in a more efficient Engineering faculty with regards to final year's projects, thus allowing the Engineering faculty to expand which then can result in a higher number of registered students to the NWU, Potchefstroom campus.

In conclusion the beneficiaries' of this study include:

- Students registered as Mechanical engineering students at the NWU, Potchefstroom campus.
- Lectures at the School of Mechanical and Nuclear Engineering at the NWU, Potchefstroom campus.
- Engineering Faculty at the NWU, Potchefstroom campus.
- The NWU, Potchefstroom campus.

2 Literature Review

2.1 NWU

For this study the School of Mechanical and Nuclear Engineering at the NWU, Potchefstroom campus, will be perceived as the case study.

Resources within the NWU Engineering Faculty include the School of Mechanical and Nuclear Engineering and the School of Chemical and Mineral Engineering. The School of Electrical, Electronic and computer Engineering did not form part of the study. (Grobler. 2013).

2.1.1 School of Mechanical and Nuclear Engineering

Table 1 contains the literature research with regards to the fourth year curriculum at the School of Mechanical and Nuclear Engineering, NWU, Potchefstroom campus. (Study guide INGM 479, 2013); (Janse van Rensburg. 2013); (Kaiser. 2013); (Van der Merwe. 2013); (Van Nieker. 2013).

From Table 1, the credits for INGM 479 indicates that for the successful completion of final year projects the number of hours that the students must spend on INGM 479 are 160 hours. Thus, for an average number of weeks, per average year, of 27 academic weeks, the number of hours that the students must spend on INGM 479, for 16 credits concludes as 6 hours, per week. This is a direct indication of the size of a final year project for INGM 479.

Table 1: Fourth year curriculum for the School of Mechanical and Nuclear Engineering

Project Classes	Individual Projects					
Student-Lecturer ratio	Number of Students :		137			
	Number of Study leaders:		13			
	Average Student-Lecture ratio:		10:1			
Fourth-year Curriculum	First Semester			Second Semester		
	Code	Module Name	Credits	Code	Module Name	Credits
	INGM 411	Thermal Machines	16	INGM 421	Machine Dynamics	16
	INGM 412	Heat Transfer	12	INGM 423	Manufacturing Technology	12
	INGM 413	Fluid Machines	12	INGM 427	Thermal Fluid System Design	16
	INGM 417	System Engineering	12	INGM471	Vacation Training Seniors	8
	INGM 417	Introduction to Project Management	8			

	INGM 414/415/416					
	Year Module					
	Code	Module Name			Credits	
	INGM 479	Project			16	
Communication	<ul style="list-style-type: none"> e-fundi Weekly individual meetings or group sessions with study-leader 					
Project Allocation	<ul style="list-style-type: none"> Project proposals are placed on the notice board and on e-fundi during the first week of November the year prior to the year of Module submission. Each student then submits four projects in order of preference on e-fundi. Projects are then allocated to students 					
Milestones	<ul style="list-style-type: none"> Milestone 1: Statement of Work Milestone 2: Literature Survey; WBS; Planning Milestone 3: Detail Design Milestone 4: Demonstration Milestone 5: Written Report Milestone 6: Project Day Milestone 7: Tool and Instrumentation Return 					
Assessment	<ul style="list-style-type: none"> Participation Mark accounts for 35% of Module mark 					
		Description	Assessment			
	Milestone 1	Oral	33%			
	Milestone 2	Written	33%			
	Milestone 3	Technical	34%			
	milestone 4	Demonstration	Go/No-go			
	Exam Admission		Minimum of 40%			
	<ul style="list-style-type: none"> Examination Mark accounts for 65% of Module mark 					
		Description	Assessment			
	Milestone 5	Report	70%			
Milestone 5	Oral	67%				
Milestone 5	Poster	33%				
Milestone 6	Presentation	30%				
External Examiner	An external examiner for each Study leader is selected from the Industry					

Workshop	For projects, which require manufacturing, each student schedules an appointment with the Workshop manager.
Budget	Each student receives a budget of R2500
	Projects

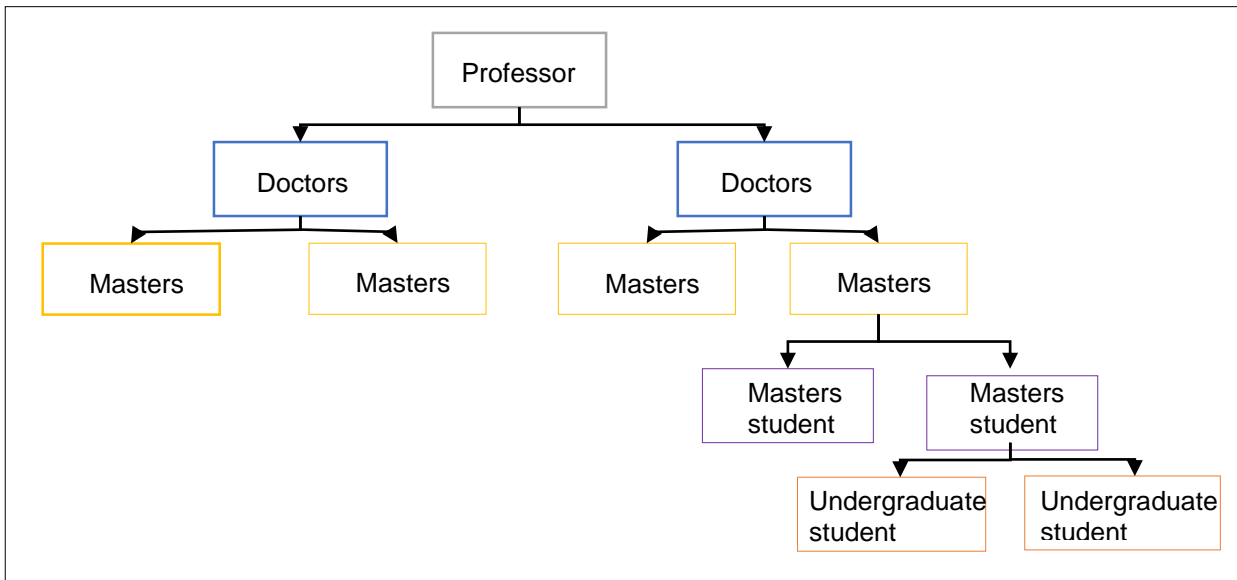


Figure 1: Top-down management approach

Dr Janse van Rensburg (2013) (Undergraduate Program Manager) compiled this management structure. Each Academic Title represents the line of management for research projects within a specific academic field. This structure allows Project-leaders to delegate work down via research projects from PhD level to undergraduate projects.

2.2 Construction of engineering final year projects

The Accreditation Board for Engineering and Technology (ABET) defines engineering design as “the process of devising a system, component, or process to meet desired needs.” An engineering capstone design experience may be defined as the crowning achievement in a student’s academic curriculum, and integrates the principles, concepts, and techniques explored in earlier engineering courses. The framework for an engineering capstone design program that has been successfully used at the undergraduate level in the Department of Systems Engineering at the United States Military Academy in West Point, New York. (Marin, et. al. 1999).

The structure for the engineering design project module is divided into three areas:

- Preparation
- Administration and execution
- Assessment.

A study was conducted by Howe and Wilbarger in 2005. This study focused on the recent trends in engineering design project courses and compared their findings against Todd et al.’s 1995 study. (Gnanapragasam, 2008).

The study found that:

- Most engineering design project courses ranged from one to two semesters long.
- Over half of the respondents had design project courses that were younger than 10 years.
- There was an increase in team based projects in 2005 compared to 1995.
- In 2005, 71% of the projects were sponsored by industry, in contrast to 59% in the 1995 study, thus suggesting that more institutions are developing a partnership with the industry.

2.3 Aspects of final- year engineering projects affecting the Management structure

Based on literature, the following aspects most affect the Management structure and are thus chosen for further research.

2.3.1 Objectives and Outcomes for a final year Engineering Project

According to Frank, M the objectives of an engineering design project are achieved through experimental learning based on the constructivism teaching principle. To achieve this, projects must:

- Provide a clear overview of the different fields in mechanical engineering.

- Introduce the essence of engineering work and the processes of design and development of new technological products.
- Increase students' awareness of the importance and necessity of analysis for finding optimal solutions for engineering problems.

Table 2 compares the outcomes and objectives of final year engineering projects against different engineering faculties.

Table 2: Objectives and Outcomes for final year Engineering Projects

Institution	ABET criteria	ECSA	NWU	Seattle University
Department	Accreditation	Accreditation	Mechanical and Nuclear Engineering	Mechanical Engineering
Engineering codes and standards				
Economic factors	X	X		X
Environmental effects	X	X		X
Sustainability	X	X		
Manufacturing	X	X		
Ethical considerations	X	X	X	X
Health and safety issues	X			
Social ramifications	X	X		X
Political factors				
Legal issues				
Problem solving techniques	X	X	X	
Alternative solutions	X	X		X
Multiple engineering disciplines	X	X		
Effective Communication	X	X	X	X

Continuous Learning	X	X		X
Integration of Knowledge		X	X	X
Project Management				X
Sources	(ABET, 2013)	(ECSA, 2012)	(Wichers, 2014)	(Rutar and Shuman, 2011)

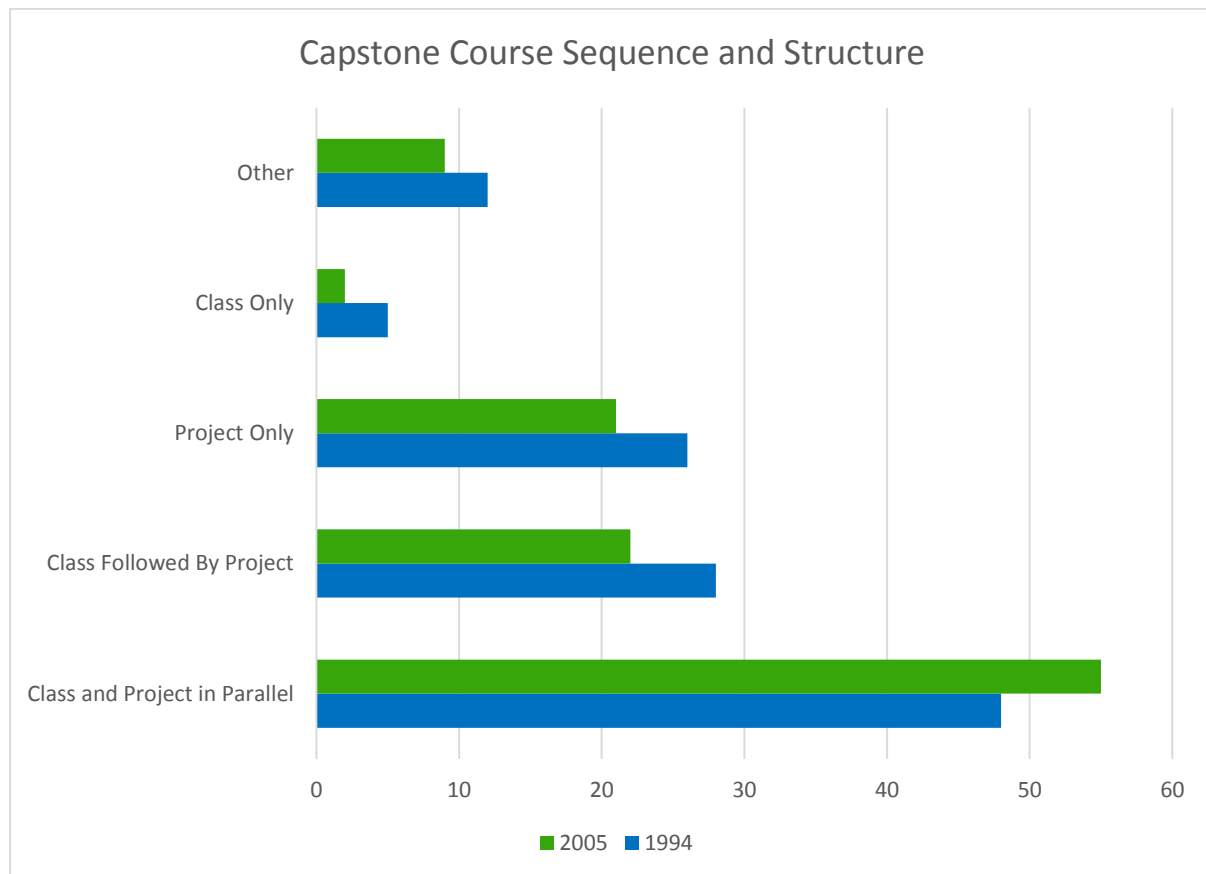
2.3.2 Requirements for the completion of final year projects

Howe conducted a national survey in 2005 as a follow-up survey from the 1994 survey on engineering capstone projects.

2.3.3 Final year project sequence

The final year project module can be divided into two sections, project and theoretical class. The theoretical class section includes topics that are essential for the successful completion of the project.

The study by Marin, et. al .in 1999 found that giving students a number of class drops in a row (no attendance required) did not prove to be successful. However by instituting design workshops where students must attend class proved to be a success. An instructor must also be present to provide guidance if students encounter problems or have questions.



Graph 1: Capstone Course Sequence and Structure

Graph 1 represents the structure and sequence of the capstone course, with regards to class and project. According to the data the majority of respondents in 2005 as well as in 1994 offered a capstone design course in parallel with design projects. There is a decrease in separate “class then project” and “project only” approach.

Theoretical requirements that are necessary for the completion of a successful final year project according to the national survey in 2005 includes: (Howe, 2010)

- Engineering ethics
- Drawing, Creativity or Concept or Generation
- Project Planning and Scheduling
- Optimization
- Sustainability
- Risk Assessment
- Engineering Economics
- Decision-Making
- Writing Abilities
- Manufacturing Processes

- Safety in Project Design
- Standard and Regulations
- Prototyping and Testing
- Product Liability
- Quality Function Development
- Analysis Tools
- CAD Design and Layout
- Intellectual Property
- Teambuilding
- Team Dynamics
- Leadership

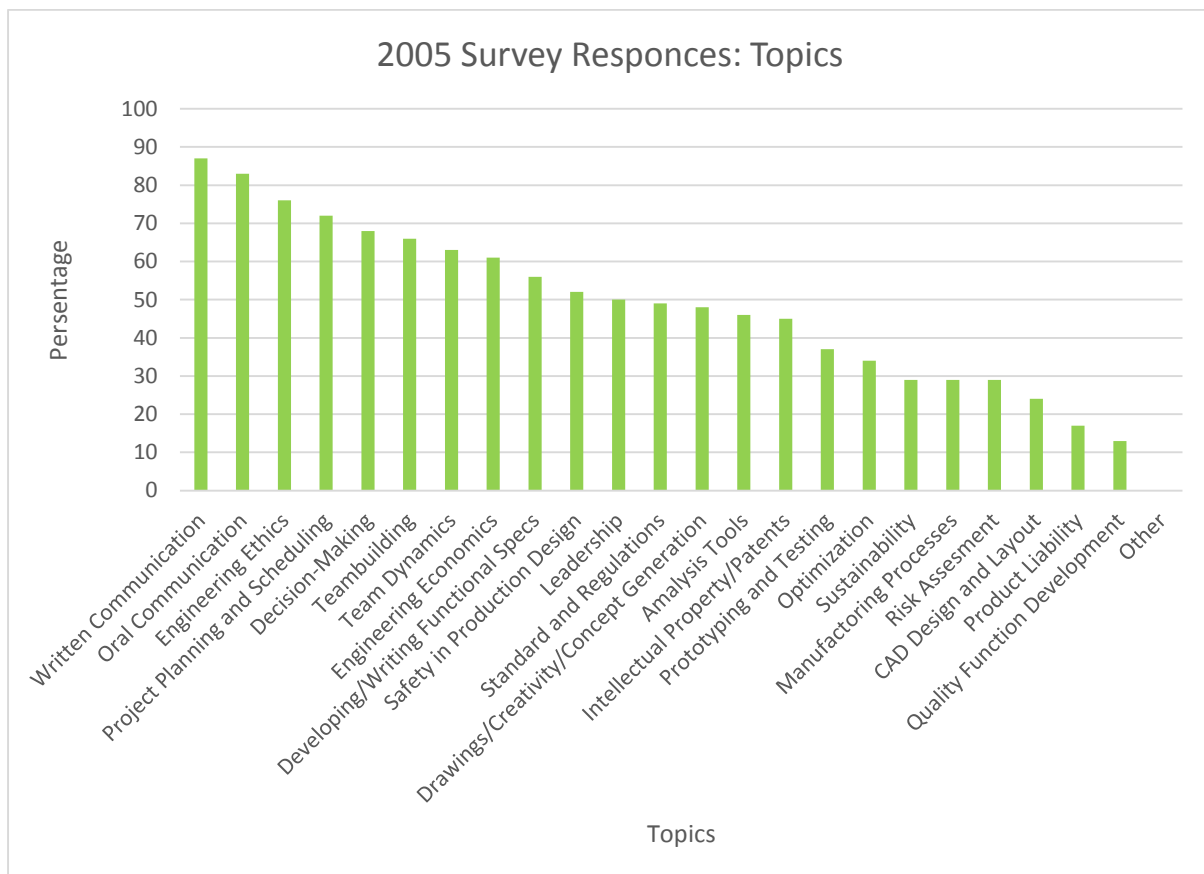


Figure 2: 2005 Survey Responses: Topics

Figure 2 indicates the percentage outcome of the survey conducted in 2005 by Howe on the most frequently taught subjects.

2.3.4 Project description for final year's projects

According to Prof Els, from the University of Pretoria (2013), final year projects must be research based. These projects must be part of an underlying research project that includes a Masters dissertation and a Doctorate thesis.

Projects must comply within the academic credits set for the relevant module

Final year projects are defined by the faculty advisor. The final outcome of a project must already be known in advance by the faculty advisor.

2.3.5 Project logistics

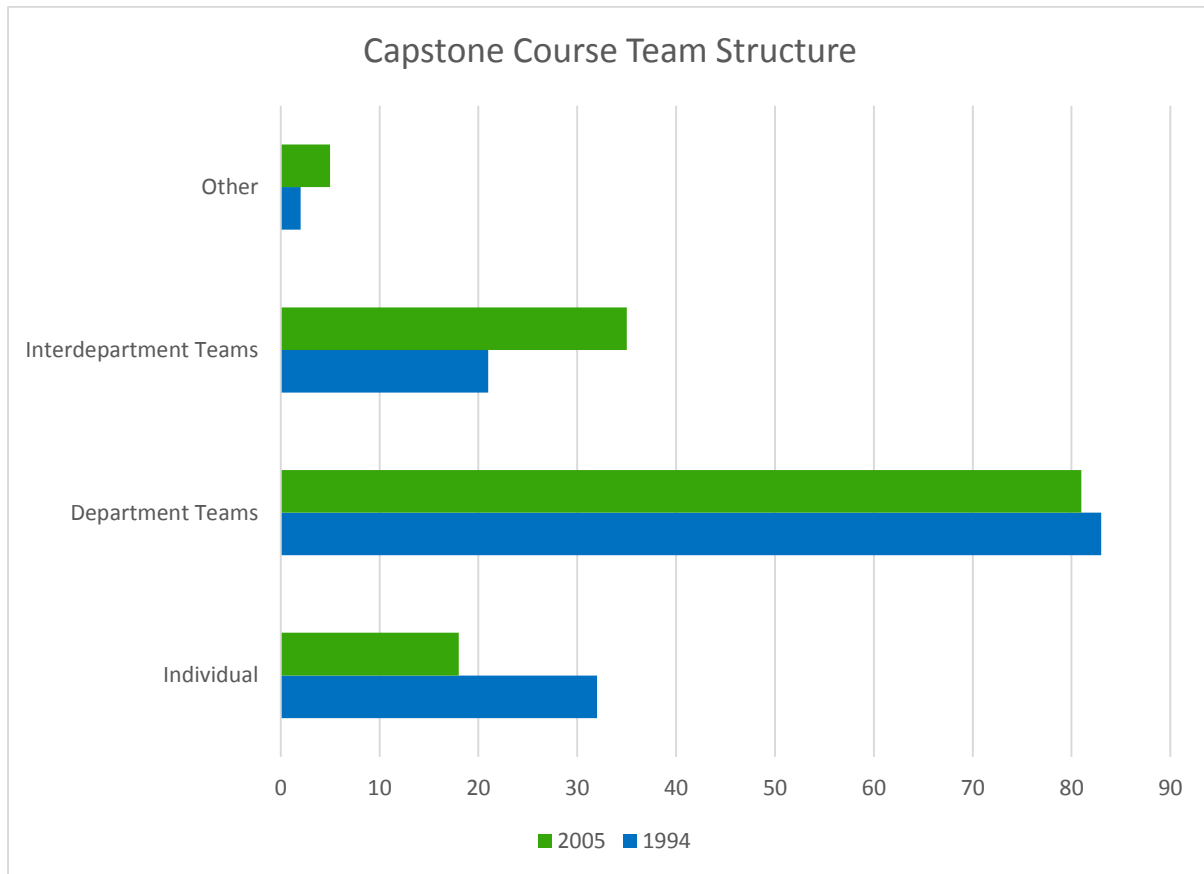
Project logistics includes the potential for group projects, individual projects and project sources.

Table 3 indicates the logistics of final year projects for SA institutes with ECSA accreditation.

Table 3 Project logistics

Institution	Individual Projects	Group Projects	Source
NWU, School for Mechanical and Nuclear Engineering	X		Kaiser, 2013
NWU, School for Chemical and Mineral Engineering	X	X	Waanders, 2013
University of Pretoria	X	X	Els, 2013
Stellenbosch Universities	X		Meyer, 2013

The national survey in 2005 on engineering capstone projects indicates that final year projects are completed individually or in teams. Team projects can be either interdepartmental or departmental. (Howe, 2010)



Graph 2: Capstone Course Team Structure

Graph 2 indicates that the majority of departments organise students around department teams in 1994 and 2005. There is also a decrease in the use of individual teams from 1994 to 2005 and an increase in interdepartmental teams.

2.3.5.1 Group projects

Advantages:

- Fosters innovation
- Economical
- Prepares students for the industry

Table 4 indicates the universities that are implementing group projects for final year projects.

Table 4: Universities implementing group projects

University	Source
University of Texas at Austin (UT-Austin)	(Nichols, 2000. 6:3900-412)
United States Air Force Academy	(Jenkins, et al. 2002, 128:2 (75))
University of Delaware	(Paul, 2005)
Center for Engineering Design and Entrepreneurship	(Bormann et al. 2012)
New Mexico Tech	(Bond, 1995. 2c3.1)
Seattle University	(Rutar and Shuman, 2011)
Brigham young University, Provo	(Zaugg and Davies, 2012. 38:2,228-233)
University of California.	(Delson, 2001. 17:4 and 5, 359-366)

For engineering design projects student teams are formed based on the following: (Gnanaprasam, 2008)

- Student interest.
- A balance of technical and communication skills.
- Compatibility within team members based on observations of instructors in previous courses.
- Consideration to diversity with regards to gender and ethnicity.

Table 5 indicates how the size of a group affects the functionality and group dynamic problems that are experienced. (Laguetta, 2011; Zaugg, 2012)

Table 5: Group sizes

Project %	Team size	Functionality	Problems associated
84 %	3-4 person team	Functioned efficiently	None
16%	5-6 person team	Functioned inefficiently	Team management Coordination Overall team dynamics

This concludes that effort must be made to limit team size to 3–4 students.

2.3.5.2 Individual Projects

Most small universities implement individual project.

Advantages:

- Student plays role as developer and manager

2.3.5.3 Project Source

Project sources influence the Management structure the most. Projects are either from the Industry, Governmental agencies and Internal.

Table 6 indicates the project sources of different universities.

Table 6: Project Sources

Institute	Project Source			Project Type		Source
	Industry	Governmental agencies	Internal	Client-based	Personal	
University of Portland	X	X				(Jones and Houghtalen, 2000)
Texas A&M University-Corpus Christi				X	X	(Bachnak and Coppinger, 2005)
Seattle University	X	X		X		(Gnanaprasam, 2008. 134:3)
University of Texas at Austin (UT-Austin)	X	X	X	X		(Nichols, 2000. 6:3900-412)
Center for Engineering Design and Entrepreneurship	X		X	X	X	(Bormann et al. 2012)
University of Arkansas at Little Rock	X			X		(Bruhn, and Camp, 2004,v36: 2)
University of California	X			X		(Delson, 2001. 17:4 and 5, 359-366)
Kettering University			X		X	(Berg and Nasr, 2002)

Eastern Mediterranean University, Cyprus			X			(Agboola, et al, 2012, 120 – 125)
NWU Mechanical and Nuclear Engineering			X	X	X	(Venter, 2013)

2.3.6 Faculty advisor

A faculty advisor is assigned to every project.

Faculty advisor requirements include:

- That a faculty advisor is a practicing professional engineer.
- Experience and expertise in a particular discipline.

Responsibilities of a faculty advisor:

- Inspire students to take ownership.
- Provide guidance and counseling to students in the technical and managerial decisions required by the project.
- Offers advice and constructive criticism.
- Fostering Creative Tension.

(Martin et. al. 1999; Bormann et al. 2012; Gnanapragasam, 2008; Zemke and Zemke, 2007; Paul, 2005)

2.3.6.1 Project Committees

Final year projects at some universities are organized and managed by Project Committees. These committees are responsible for all the aspects that involve final year projects from project sources to project funding.

Table 7 indicates universities implementing Projects Committees.

Table 7: Universities implementing Project Committees

University	Source
Franklin W. Olin College of Engineering	(Chang and Townsend, 2008)
Texas A&M University-Corpus Christi	(Bachnak and Copponger, 2005)
Gonzaga University School of Engineering	(Bormann et al. 2012)

2.3.7 Project Initiation

Gnanapragasam (2008) describes the following procedure for project initiation.

- Class 4 hours per week.
- Industry experts spends approximately 1 of the lecture hours each week conducting seminars with regards to:
 - project management
 - planning and scheduling
 - team building and team dynamics
 - intellectual property rights
 - confidentiality and proprietary issues
 - proposal preparation and evaluation of proposals in the real world
 - networking
 - job search
 - professional licensing
 - and development of other soft skills necessary in engineering.
- The teams spend 3 months on:
 - understanding the project
 - sponsor requirements
 - brainstorming alternatives
 - breaking down the project into various tasks and deliverables.
- A written proposal is prepared on the:
 - description of the project
 - scope of work
 - plan of implementation
 - list of tasks and deliverables
 - project schedule
 - budget

Various internal and external constituencies review the proposal and provide feedback to the teams.

2.3.7.1 Project Implementation and Completion

Sequence for group projects according to Gnanapragasm:

- The first 6 months are spend on performing the design, field, or laboratory work as applicable. During this time teams continue to meet with the faculty advisor weekly and with the sponsor liaison (for industry projects) preferably every other week throughout the academic year.
- For the last 6 months the class meets once a week to review administrative details and for periodic oral presentations by the team. The teams spend the rest of the time on the project. (Gnanapragasam, 2008)

For Industry projects the project deliverables are reviewed by the faculty advisor prior to submission to the sponsor liaison. At the end of 6 months, teams submit a partially completed project report to the department. This report consists out of: (Gnanapragasam, 2008)

- A draft report outline.
- Project description.
- Tasks and deliverables completed to date.
- Appendices compiled so far.

This timeframe ensures that the teams compile the information early and formulate the report without procrastinating.

At least two more drafts of the project report must be completed to ensure a thorough report.

The project concludes with “Projects Day”. Projects are presented orally and through posters. Project presentations are presented to the campus community, alumni, and local engineering community of current and potential sponsors. The public view ensures that students experience the demands and atmosphere of a professional conference.

On “Projects Day” the final design-report is submitted. (Gnanapragasam, 2008)

The project procedure describes the major tasks and sequence, in which they are to be completed in order to be able to successfully complete the final year project.

Table 8: Project Procedure

Task	Description	Person Responsible	Time
Industry sponsors	Letters are sent to potential industry project sponsors.	Project-advisor	Five-week period in the semester preceding the capstone course.

Project screening	<p>Project-advisors screen projects according to:</p> <ul style="list-style-type: none"> • Solvability in 200-400 man-hours. • Projects must require re-search and design. • Projects must requires a team of 2-3 students. • Projects must not be with mainstream production. • Material and equipment for the projects must be easily available. 	Project-advisor	Five-week period in the semester preceding the capstone course.
Project description	Details of projects are carefully worked out.	Project-advisors	One week.
Publication of Projects	Projects are submitted to students.	Project-advisors	One week after project description.
Project selection by students	<p>Project selection process by students:</p> <ul style="list-style-type: none"> • Listing all the projects. • Filter projects by considering long term goals. • Filter the new set of projects by considering short term goals. • Filter the new set of projects by considering the senior capstone course requirements. • Filter the last set of projects by considering available resources. Resources include: <ul style="list-style-type: none"> • time • money 	Students	One week after Publication of projects.

	<ul style="list-style-type: none"> • technical knowledge • Select a project from the last filtered set of projects. 		
Project Allocation	<ul style="list-style-type: none"> • Project-advisors are assigned to specific projects which are in accordance to their line of expertise. • Students are assigned to teams with regards to the projects that they selected. • Project allocations and teams are published. 	Project-advisors	One week after Project selection.
Team meeting	<ul style="list-style-type: none"> • Teams conduct their initial meeting and begin developing plans to learn more about their assigned project and sponsor. 	Students	Week prior of Project allocation.
Meeting with Project-advisor	<ul style="list-style-type: none"> • Students schedule meetings with the Project-advisor. • There is at least one scheduled, one-hour meeting with an instructor during this period. 	Students Project-advisor	Week prior of Project allocation.
Class	<ul style="list-style-type: none"> • Tutorials and lectures are conducted regarding: <ul style="list-style-type: none"> ○ teamwork ○ project management ○ effective presentations ○ time management ○ cost/benefit analysis ○ writing company memos ○ dealing with difficult interpersonal situations • Students are made aware of facilities and administrative support that are at their 	Students Faculty	Next two weeks.

	<p>disposal to conduct their projects.</p> <p>These include:</p> <ul style="list-style-type: none"> ○ shop facilities ○ computer laboratories and software project administrators. 		
Meeting with industry advisor	<p>Team meet their industry advisor. The advisor presents the requirements of the project.</p>	<p>Students Industry liaison</p>	
Proposal	<p>Students must prepare:</p> <ul style="list-style-type: none"> • A proposal plan. This includes: <ul style="list-style-type: none"> ○ Project requirements ○ Approach ○ Task breakdown ○ Task estimates (in hours) ○ Responsibilities of each student ○ Output of each student ○ Schedule of outputs • A design reviews • A final presentation • A final report 	<p>Students</p>	<p>Week one.</p>
Proposal Presentation	<p>Students must submit a written copy of their project proposal and present their proposal in the form of a presentation to the class.</p>	<p>Students</p>	
Presentation to Industrial sponsors	<p>Students are required to make a presentation to the industrial sponsor's management at the sponsor's site. A copy of their</p>	<p>Students Industry liaison</p>	

	proposal is also presented to the sponsor.		
Meetings	<ul style="list-style-type: none"> Students conduct their team project investigation interfacing mainly with the industrial sponsor's liaison engineer and visiting the industrial plant site. Team are coached and advised, particularly with regard to problems that have impeded its progress. 	Students Project-advisor Industry liaison	Every two weeks.
Meetings	Teams meet with a panel consisting of faculty, industrial visitors, and graduate students. During this panel meeting, the teams are interrogated regarding their progress, decisions, and investigative approach.	Students Project-advisor Industry liaison	Every two weeks.
Progress report presentation	Teams are required to submit a written progress report and present this report orally to the class.	Students	Week 7 of first semester.
Report presentation	Written and oral reports are presented to the sponsor.	Students Industry liaison	
	Conducted much the same as the previous three weeks with meetings, sponsor visits, and panel sessions.	Students Project-advisor Industry liaison	Next six weeks.
Report submission	The teams' written final reports are due.	Students	The last week of classes.
Final examination	Final presentation of project.	Students Project-advisor Industry liaison	Week prior to report submission.

(Laguetta, 2011; Bachnak and Coppinger, 2005; Gnanapragasam, 2008; Nichols, 2000: 412; Bormann et al. 2012; Bruhn and Camp, 2004:2; Butkus and Kelley, 2004:174; Ruud and Delveaux, 1997:644-647)

2.3.7.2 Meeting Deadlines

- Students are expected to meet all deadlines
- For team projects, team members are required to maintain a project notebook which should at least contain the team meeting notes of:
 - Action items resulting from each meeting
 - Tasks delegated and a record of completion
 - A record of phone logs with sponsors, suppliers, etc.

2.3.8 Comprehensive Exam and Reflection Essay

Comprehensive exam and reflection essays are useful to assess some of the outcomes, although they are not related to engineering design projects. (Gnanapragasam, 2008)

Table 9 summarizes the different assessment tools used during the capstone experience to evaluate the program outcomes. (Gnanapragasam, 2008)

Table 9: Assessment tools

Fundamentals	Performance in the comprehensive exam
Design	Evaluation of final reports Responses of sponsor surveys
Teamwork	End of the quarter peer review and faculty evaluation
Problem solving	Performance in the comprehensive exam
Ethics	Performance in the comprehensive exam Evaluation of final reports Responses of sponsor surveys
Communication	Evaluation of oral presentations, proposals, and reports
Global awareness	Evaluation of reflection paper Evaluation of final reports Responses of sponsor surveys
Lifelong learning	Evaluation of all project deliverables
Modern skills	Evaluation of oral presentations

2.3.9 Project Selection

Design project must relate to areas of the faculty's academic background or disciplinary expertise. (Marin, et. al. 1999; Markgraaff, 2015; Els, 2013)

According to Els (2013) projects should be in line with the research fields in each faculty. This includes postgraduate level (PhD and M) and undergraduate level. By using this line, multiple sources can be focused on one research field. This provides less strain on faculty advisors, research heads are responsible for PhD level, PhD level are responsible for M projects and M Projects are responsible for undergraduate projects. Refer to figure 2 for the research flow structure. This structure is also in compliance with Figure 3, thus reinforcing the implementation of using higher qualified project heads to supervise lower qualified projects within the same research line.

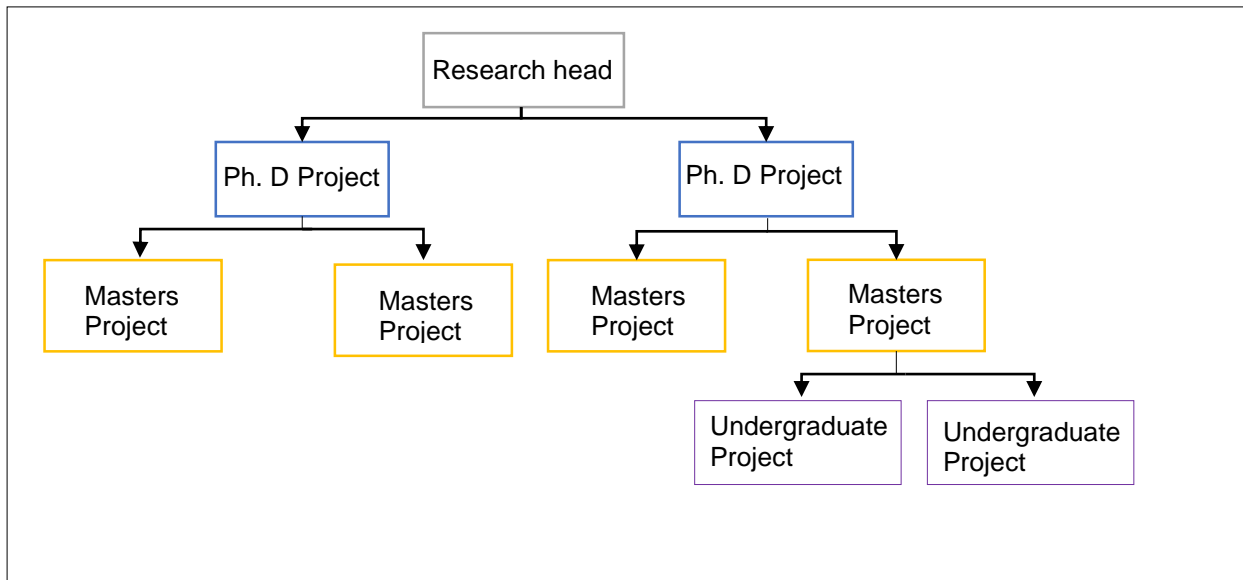


Figure 3 Research flow structure

2.4 A Project Management Approach

Implementing appropriate project management tools addresses all challenges faced with engineering design projects. The primary goal is not to teach project management but to improve the project experience and final year Project quality while minimizing instructor interference. (Moor and Drake, 2001)

2.4.1 Project Management Framework

The performance of an organization is most affected by the organization structure, organization design, organization chart and organization dimensions.

The organization structure serves a significant role with regards to the effectiveness of the organization in project orientated organizations. The organization structure specifies the employee's tasks, reporting system, and formal coordinating mechanisms as well as interaction partners that will be followed.

Organization design includes any macro-property of an organization. This includes the organizations formal architecture, culture, strategy and employment relationships. One element of the organization design process is the organization chart. This is a visual representation of the underling activities and processes in an organization. The project team and project matrix is considered elements of an organization chart that could improve the effectiveness of a project-based organization.

There are two types of organizational dimensions. These types consist out of the structural and contextual dimensions. The structural dimensions refer to the internal characteristics of an organization that assesses the organization. The contextual dimensions characterize the whole organization. This includes the size, technology, culture, environment, and strategy of the organization. The contextual dimensions describe the organizational settings which influence and shape the structural dimensions. A study by Chandler (2008) concluded that the structure of an organization follows its strategy. Thus the change in the economic environment leads to the development of new strategies which then leads to a new organizational structure. This chain reaction is also true for other contextual dimensions of an organization. For the type of technology used affects the structural dimensions of an organization like formalization, centralization and span of control.

The six primary structural dimensions of organizational structure include: specialization, standardization, formalization, centralization, configuration, and flexibility. (Sepehri, et al. 2011)

One aspect of the organization design process is organization chart. The research aims to design a proper organizational chart for the final year Projects at the School of Mechanical and Nuclear Engineering at the North-West University, Potchefstroom Campus.

2.4.2 Project Organization Structure

A project organization structure facilitates the coordination and implementation of project activities. The project organization structure is an important aspect of project. The organization structure reduces uncertainty and confusion that typically occurs at the project initiation phase.

The structure is used to define the relationships among members of the project management and the relationships with the external environment. The structure defines the authority by means of an organization chart.

All projects are unique and the organization structure should be designed around the organizational environment, the project characteristics in which it will operate and the level of authority the project manager is given.

2.4.2.1 Types of project organization structure:

- Programmatic Based

In this structure the program sector managers have formal authority over most resources. It is suitable for projects that require one program sector. (pm4dev. 2007; Clements, and Gido, 2012)

Advantages:

- Clear line of authority.
- Team members are familiar with each other.

Disadvantages:

- Program area does not have the specialists needed for project.
- Project members may have other responsibilities.

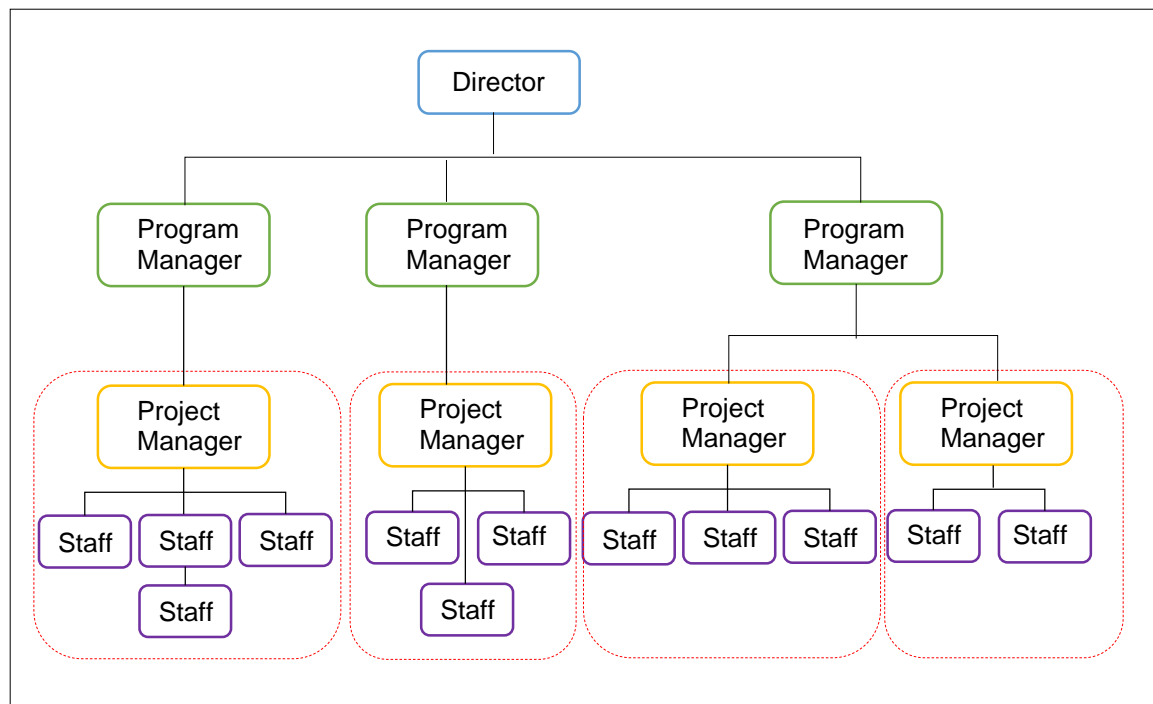


Figure 4: Programmatic Based Management Structure

Figure 4 indicates the schematic illustration of the Programmatic Based Management Structure.

- Matrix Based

This structure allows program units to focus on their specific technical competencies and allow projects to be staffed with specialists from throughout the organization. (pm4dev. 2007; Clements, and Gido, 2012)

Advantages:

- Effective allocation of resources.
- Flexible.
- More efficient information sharing.

Disadvantages:

- Complex reporting relationships.
- Strong time management skills.
- Ineffective communication.

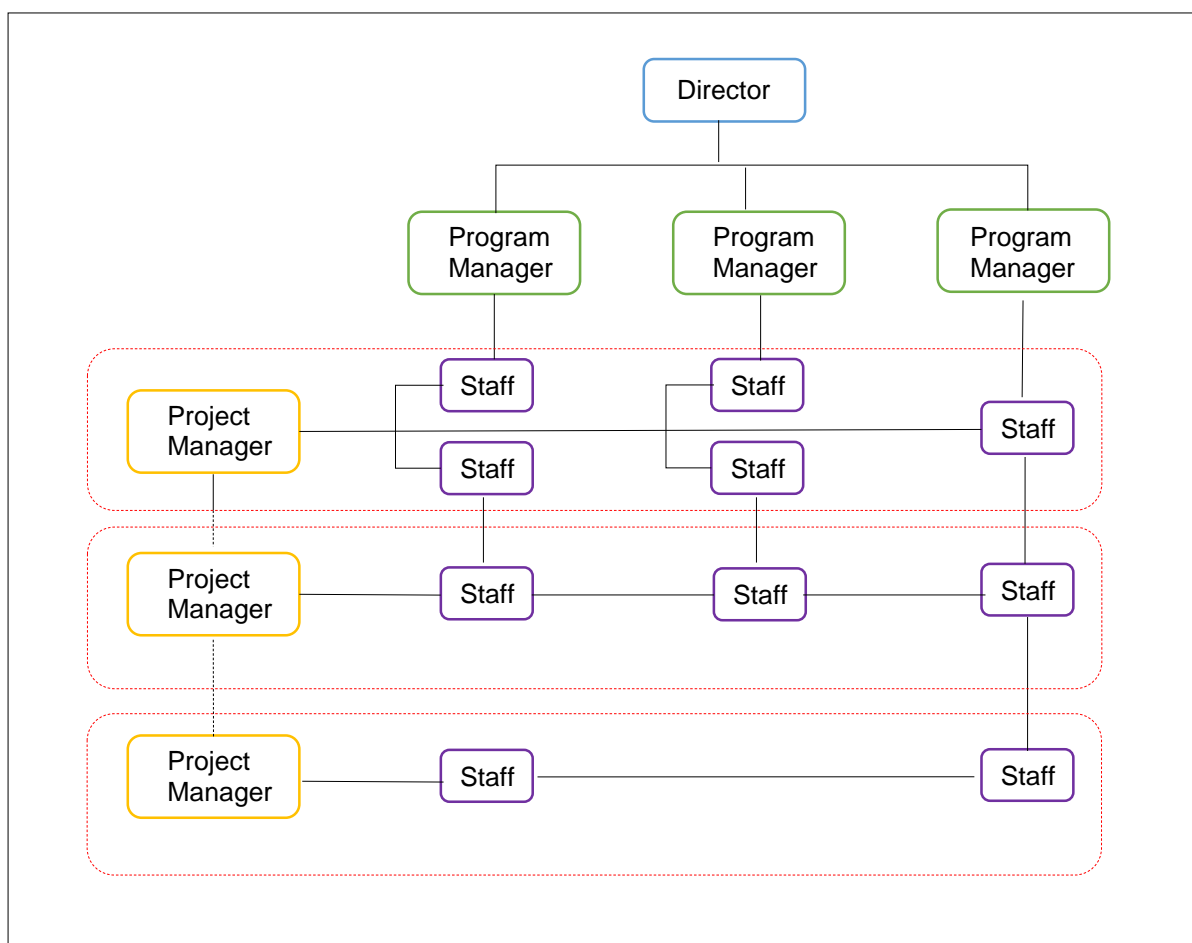


Figure 5: Matrix Based Management Structure

Figure 5 indicates the schematic illustration of the Matrix Based Management Structure.

- **Project Based**
 Project managers have a high level of authority to manage and control the project resources. Personnel are specifically assigned to the project and report directly to the project manager. Pure project based organizations are implemented among large and complicated projects. (pm4dev. 2007; Clements, and Gido, 2012)

Advantages:

- Increase project loyalty
- Strong project controls and centralized lines of communication.

Disadvantages:

- Costly and inefficient use of personnel.
- Limited information sharing.
- Duplication of resources.

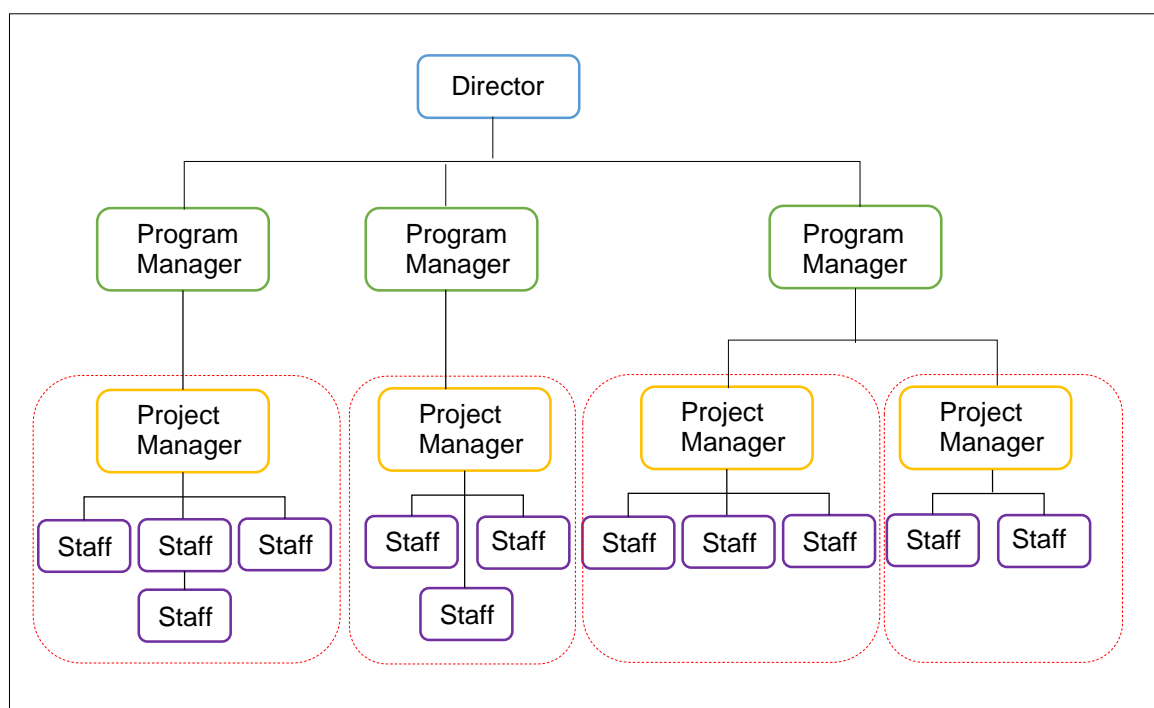


Figure 6: Project Based Management Structure

Figure 6 indicates the schematic illustration of the Project Based Management Structure.

3 Research Methodology

For this study the impact of an engineering final year project is based on the findings at the North West University Engineering faculty at the Potchefstroom campus. The data collected for this study is thus based on the North West University Engineering faculty, Potchefstroom campus. Other universities were also contacted to compare and verify the results obtained.

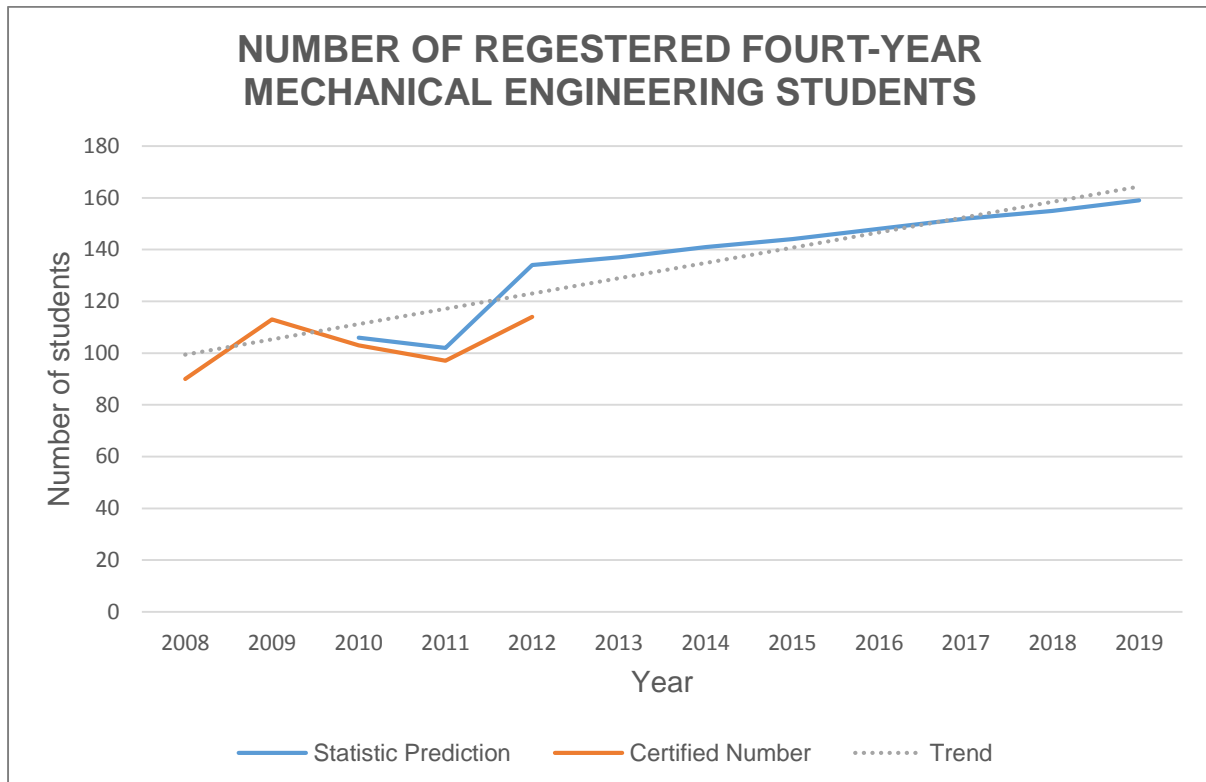
The current problem experienced by the School of Mechanical and Nuclear Engineering is the workload. The academic lecturers at the school are also project advisors and the workload that goes with the ability to fulfil in both roles is becoming problematic, especially due to the increasing number of registered final year Mechanical Engineering students.

3.1 Number of Registered fourth-year Mechanical Engineering students

The data in Table 10 contains the data provided by Mrs. E Hatting from the Engineering faculty of the North-West University at the Potchefstroom campus. The data for Table 10, row 2, contains the number of students from 2008 till 2012 that were registered as fourth year mechanical engineering students at the university. The data for the Statistical Prediction of the Number of Students contains the statistic number of students which will register as fourth year mechanical engineering students for 2010 till 2019. The statistic number of students were determined by the Engineering faculty of the North West University for the Potchefstroom campus. The data only indicates the number of registered fourth year students and not the students that were registered for INGM 479. The curriculum at the school of Mechanical and Nuclear Engineering indicates that a student must be in his/hers final year of study to be able to register for INGM 479 thus the conclusion can be drawn that students who register as fourth year students also register for INGM 479.

Table 10: Number of registered fourth-year Mechanical Engineering Students from 2008 till 2019

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Certified Number of Students	90	113	103	97	114							
Statistic Prediction of the Number of Students			106	102	134	137	141	144	148	152	155	159



Graph 3: Number of registered fourth-year Mechanical Engineering students

Graph 3 shows the Number of registered fourth-year Mechanical Engineering students, this indicates the Statistic Prediction as well as the Certified Number of students that will be registered as fourth year students at the North West University at the Potchefstroom campus from 2008 till 2019. The graph shows an increase in value for both the statistical prediction and the certified number. From the Trend line it can be seen that there is a linear increase for registered students. The data confirms that the School for Mechanical and Nuclear Engineering will be experiencing an increase of registered students.

From the data the gradient of the trend line can be calculated by equation 11 and concludes that the Trend line gradient is 6.81. This indicates a dramatic increase of the number of student registrations from 2008 to 2019.

3.2 Number of hours each Project-leader spends on Project-leader related work.

To be able to determine the scope of the problem encountered a survey was conducted to determine the number of hours that each project-leader spends on project related work. For survey refer to Appendix A.

The number of hours that each Project-leader spends on Project Leader related work is divided into 3 areas:

- The minimum number of hours each Project-leader spends on Project Leader related work.
- The average number of hours each Project-leader spends on Project Leader related work.
- The maximum number of hours each Project-leader spends on Project Leader related work.

3.2.1 Minimum number of hours each Project-leader spends on Project-leader related work

For the minimum number of hours the minimum time indicated from the Survey Question 8 (for survey refer to Appendix A) is used to determine the number of hours spend by each Project-leader on project-leader related work for each milestone.

Table 11: Minimum number of hours spent by each project leader on each milestone

Milestones	Hours
Project Planning	0.27
Milestone 1	0.09
Milestone 2	0.45
Milestone 3	0.82
Milestone 4	0.82
Milestone 5	1.18

From Table 11, the minimum number of hours spent by each project-leader for each student per day is calculated over the time period as indicated in Table 10 from 2008 to 2019.

The average hours per milestone per week for the minimum number of hours each Project-leader spends on project-leader related work is calculated with Equation 2.

Average minimum hours per Milestone=0.6060606 [h]

In Table 12, the minimum number of hours per week for all the students is calculated with Equation 3.

Table 12, indicates the minimum number of hours per week that the Project-leaders will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019

Table 12: Average minimum hours per week

Year	Minimum hours per week for all students
2010	60.61
2011	54.55
2012	76.97
2013	83.03
2014	85.45
2015	87.27
2016	89.7
2017	92.12
2018	93.94
2019	96.36

In Table 13, the minimum number of hours each Project-leader spends each week on project-leader related work is calculated with Equation 4.

Table 13, indicates the minimum number of hours per week that each Project-leader will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

Table 13: Minimum number of hours per Project-leader per week

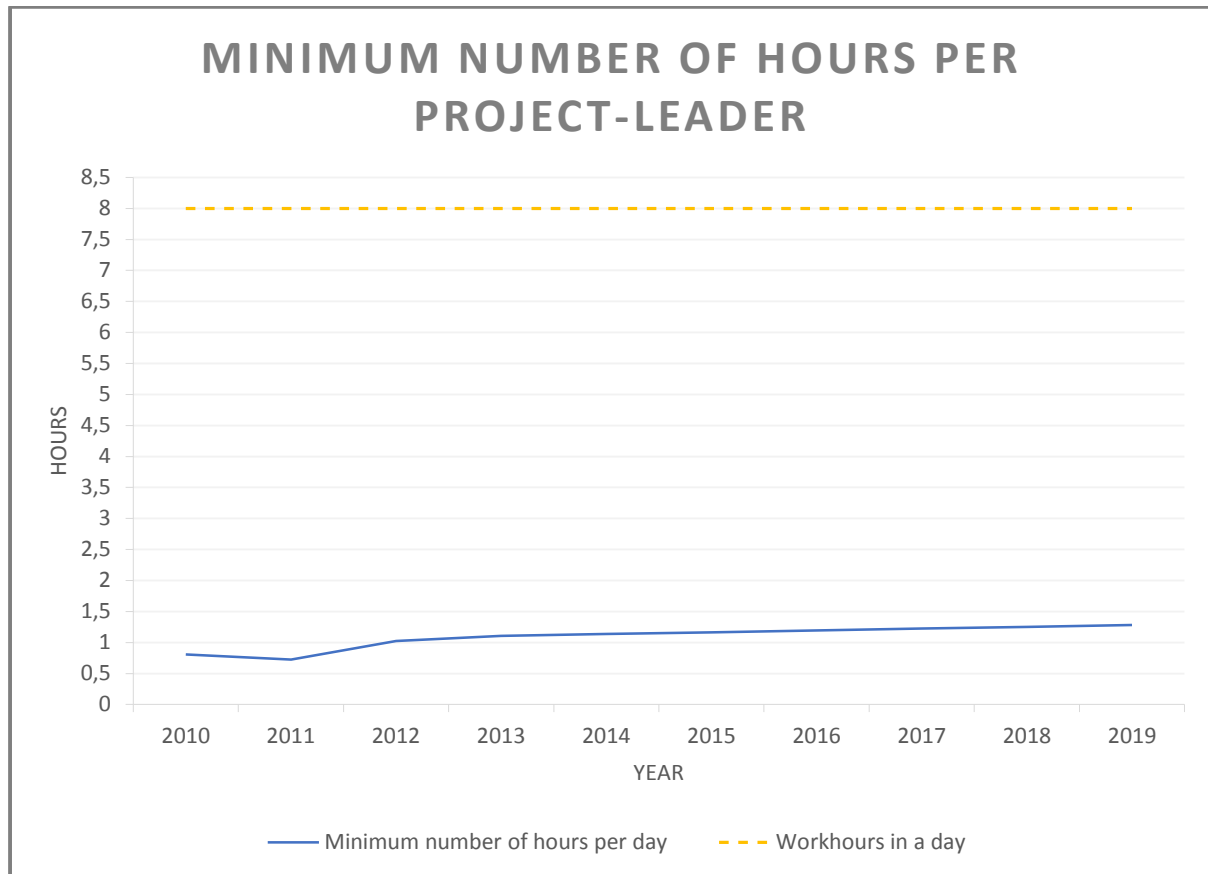
Year	Minimum hours per Project-leader per week
2010	4.04
2011	3.64
2012	5.13
2013	5.54
2014	5.7
2015	5.82
2016	5.98
2017	8.37
2018	6.14
2019	6.42

For Table 14, the minimum number of hours per Project-leader per day is calculated using Equation 5.

Table 14 indicates the minimum number of hours, per day, which each Project-leader will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

Table 14: Minimum hours per Project-leader per day

Year	Minimum hours per Project-leader per day
2010	0.81
2011	0.73
2012	1.03
2013	1.11
2014	1.14
2015	1.16
2016	1.2
2017	1.23
2018	1.25
2019	1.28



Graph 4: Minimum Number of Hours per day per Project-leader

Graph 4 indicates the minimum number of hours per day that each Project-leader will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

3.2.2 Average number of hours each Project-leader spends on Project-leader related work

For the average number of hours, the average between each time slot as indicated on Survey Question 8 (for survey refer to Appendix F) was calculated using Equation 1.

Table 15: Average number of hours spent by each project leader on each milestone

Milestones	Hours
Project Planning	0.86
Milestone 1	0.68
Milestone 2	0.86
Milestone 3	1.23
Milestone 4	1.23
Milestone 5	1.59

From Table 15 the average hours spent by each lecturer for each student per day is calculated over the time period as indicated in Table 10.

The average hours per milestone per week is calculated with Equation 2.

$$\text{Average hours per milestone} = 1.07575758 \text{ [h]}$$

In Table 16, Table 16 indicates the average number of hours per week Project-leaders will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019. The average hours per week for all the students is calculated with Equation 3.

Table 16: Average hours per week

Year	Average hours per week for all students
2010	107.58
2011	96.82
2012	136.62
2013	147.38
2014	151.68
2015	154.91
2016	159.21
2017	163.52
2018	166.74
2019	171.05

For Table 17, the average number of hours per Project-leader per week is calculated with Equation 4.

Table 17 indicates the average number of hours per week which each Project-leader will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

Table 17: Average hours per Project-leader per week

Year	Average hours per Project-leader per week
2010	7.17
2011	6.45
2012	9.11
2013	9.83
2014	10.11

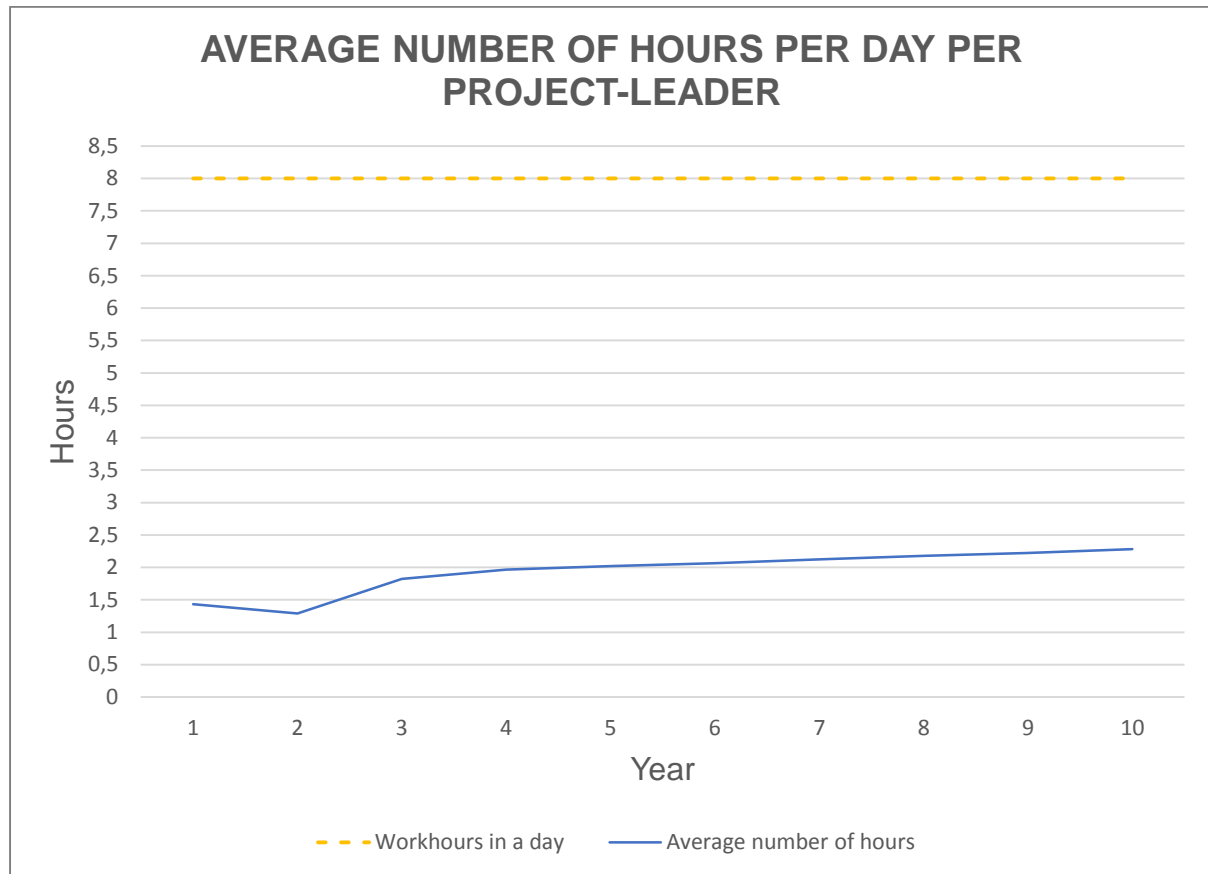
2015	10.33
2016	10.61
2017	10.90
2018	11.12
2019	11.40

In Table 18, the average number of hours is calculated with Equation 5.

Table 18 indicates the average number of hours per day that each Project-leader will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

Table 18: Average hours per Project-leader per day

Year	Average hours per Project-leader per day
2010	1.434343
2011	1.290909
2012	1.821616
2013	1.965051
2014	2.022424
2015	2.065455
2016	2.122828
2017	2.180202
2018	2.223232
2019	2.280606



Graph 5: Average Number of Hours per Day per Project-leader

Graph 5 indicates the average number of hours, per day, that each Project-leader will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

3.2.3 Maximum number of hours each Project-leader spends on Project-leader related work

Table 19 contains the maximum number of hours that each Project-leader spends per week on project-leader related work for the milestones as indicated.

Table 19: Maximum number of hours spent by each Project-leader per week on each milestone

Milestones	Hours
Project Planning	1.09
Milestone 1	0.91
Milestone 2	1.36
Milestone 3	1.55
Milestone 4	1.64
Milestone 5	2

From Table 19, the maximum number of hours spent by each lecturer for each student per day is calculated over the time period as indicated in Table 10.

The maximum number of hours per milestone per week is calculated with Equation 2.

Maximum number of hours= 1.4242 [h]

For Table 20 the maximum number of hours per week for all the students is calculated with Equation 3

Table 20 indicates the maximum number of hours per week that Project-leaders will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

Table 20: Maximum hours per week

Year	Maximum hours per week for all students
2010	142.424242
2011	128.181818
2012	180.878788
2013	195.121212
2014	200.818182
2015	205.090909
2016	210.787879
2017	216.484848
2018	220.757576
2019	226.454545

For Table 21, the maximum number of hours per Project-leader per week is calculated with Equation 4.

Table 21 indicates the maximum number of hours per week that each Project-leaders will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

Table 21: Maximum number of hours per Project-leader per week

Year	Maximum hours per Project-leader per week
2010	9.49
2011	8.55
2012	12.06

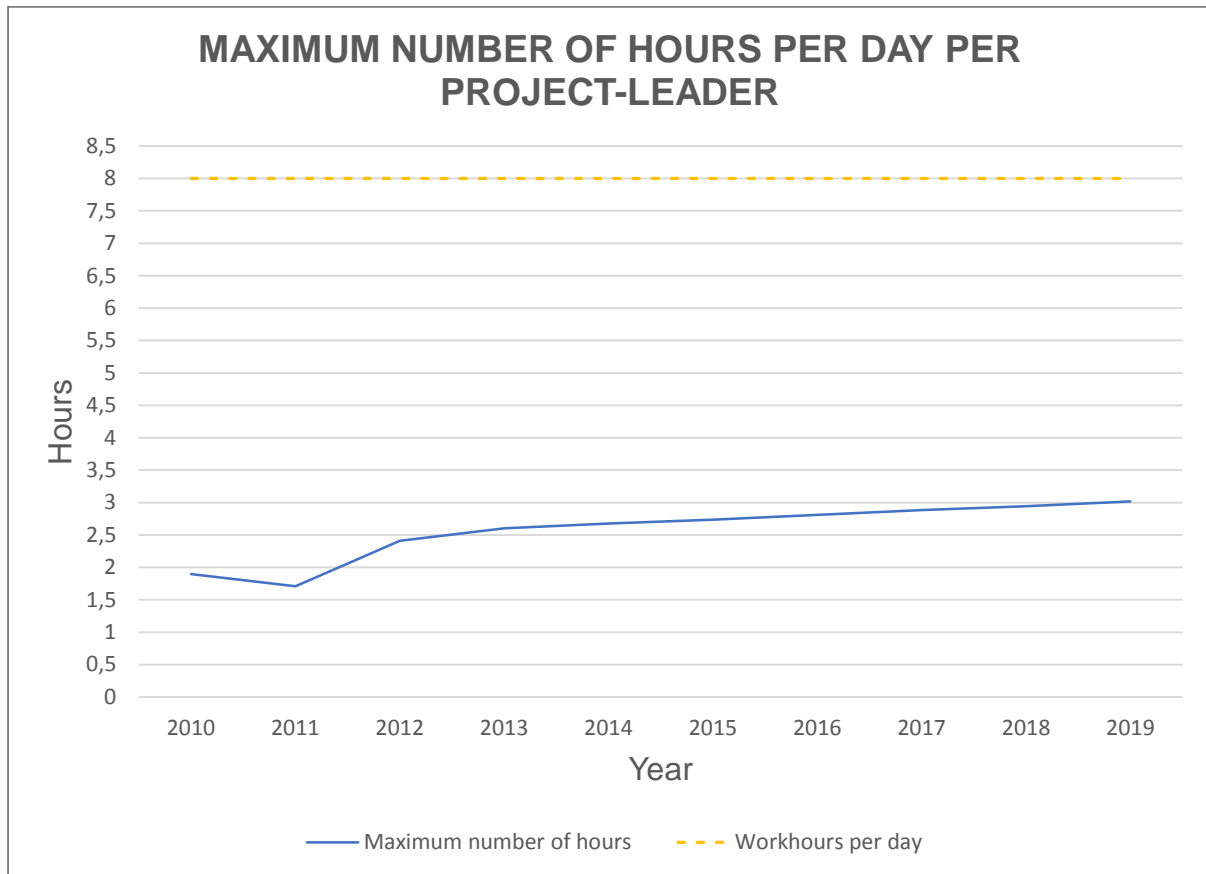
2013	13.01
2014	13.39
2015	13.67
2016	14.05
2017	14.43
2018	14.72
2019	15.10

For Table 22, the maximum number of hours per Project-leader per day is calculated with Equation 5.

Table 22 indicates the maximum number of hours per day that each Project-leader will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.

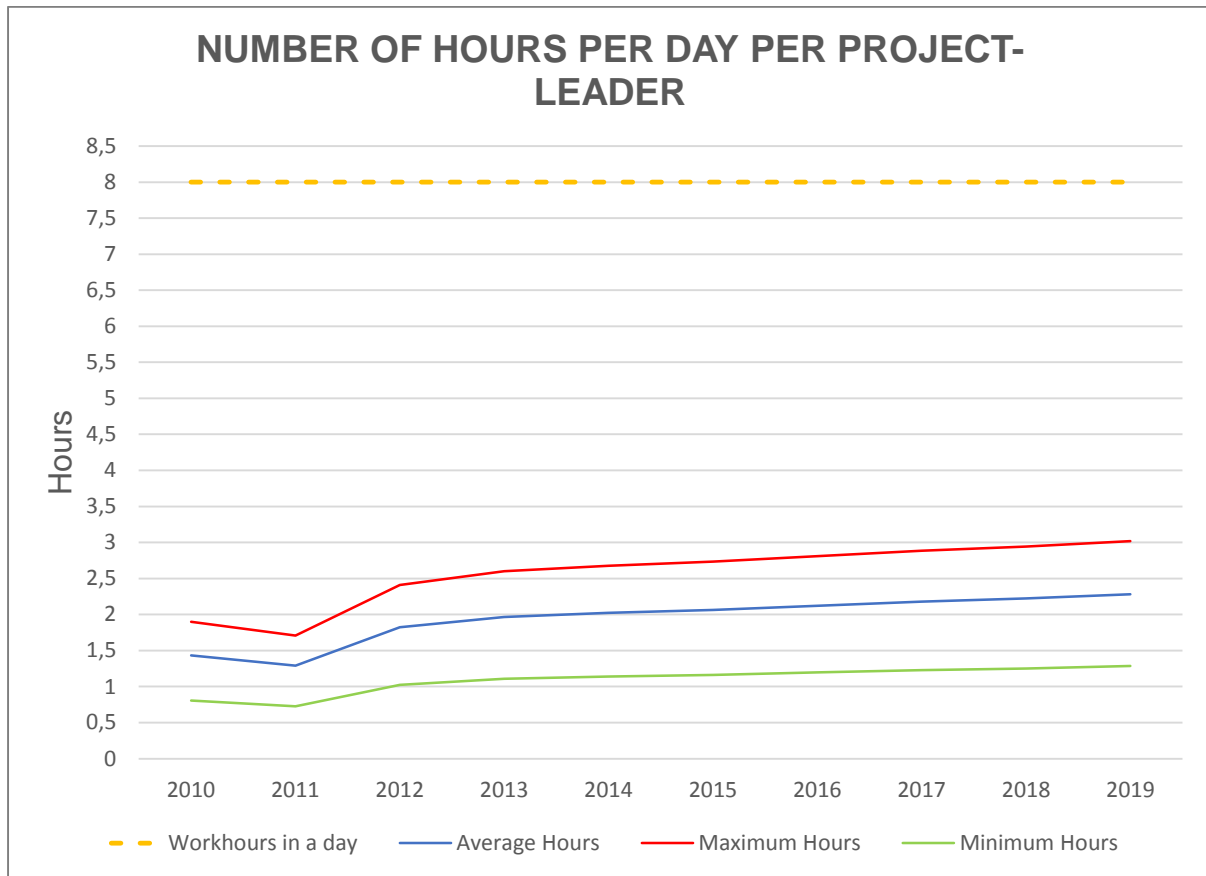
Table 22: Maximum number of hours per Project-leader per day

Year	Average hours per Project-leader per day
2010	1.90
2011	1.71
2012	2.41
2013	2.60
2014	2.68
2015	2.81
2016	2.81
2017	2.89
2018	2.94
2019	3.02



Graph 6: Maximum Number of Hours per Day per Project-leader

Graph 6 indicates the maximum number of hours, per day, that each Project-leader will spend on Project-leader related work for the number of students registered as fourth year Mechanical Engineering students from 2010 to 2019.



Graph 7: Number of Hours per day per Project-leader

Graph 7 indicates the Maximum, Average and Minimum number of hours each lecturer spends per day on Project-leader related work.

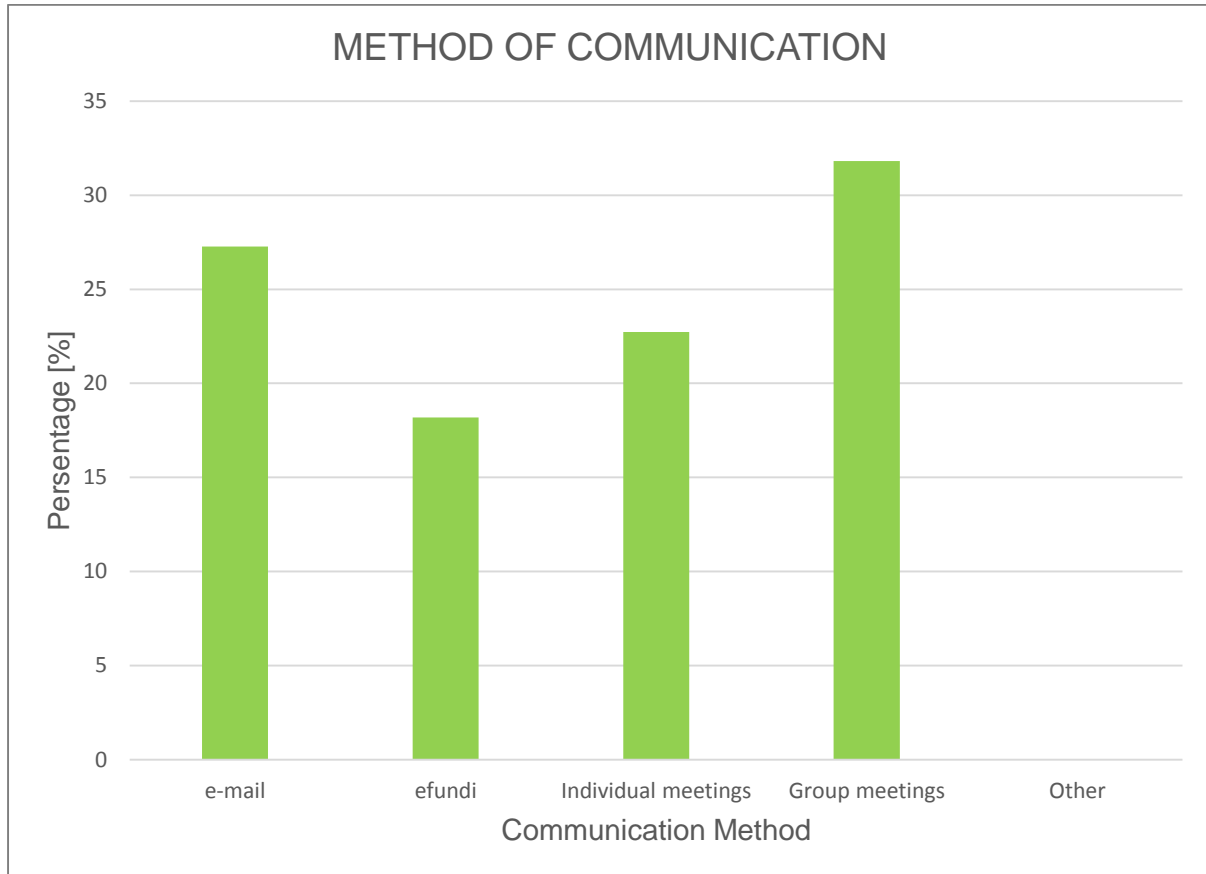
3.3 Communication between Project-leaders and students

From Survey Question 7 (refer to Appendix A) the preferred method of communication by project leaders with students can be determined.

Table 23 indicates the method of communication project leader's use to communicate with their students, with regards to the time periods. From Table 23 it can be seen that the preferred method of communication is group meetings and individual meetings.

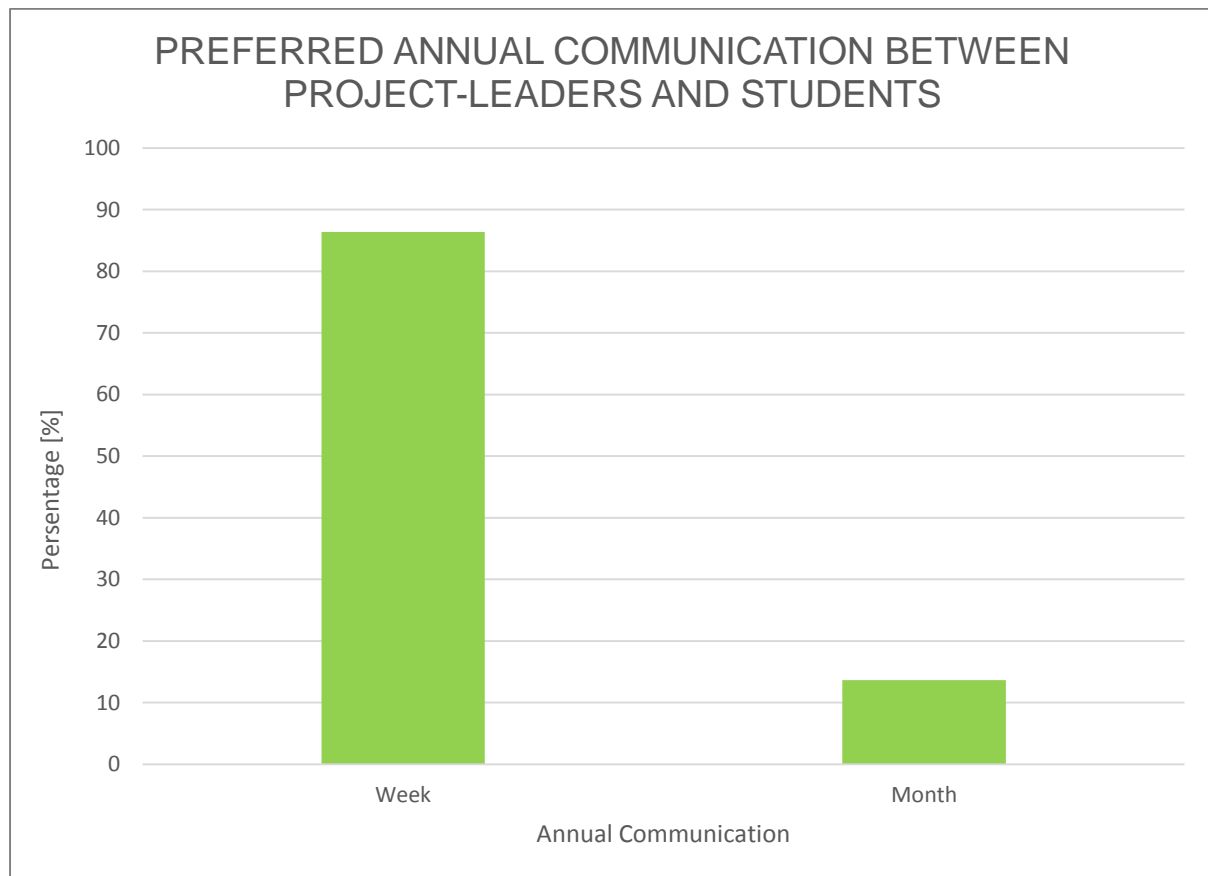
Table 23: Method of communication with students with regards to the time periods

	On a Weekly basis	On a monthly basis	On a termly basis	In a semester
e-mail	5	1	0	0
efundi	2	2	0	0
Individual meetings	5	0	0	0
Group meetings	7	0	0	0
Other	0	0	0	0



Graph 8: Preferred Method of Communication

Graph 8 indicates the preferred method of communication for Project leaders and students for INGM 479.

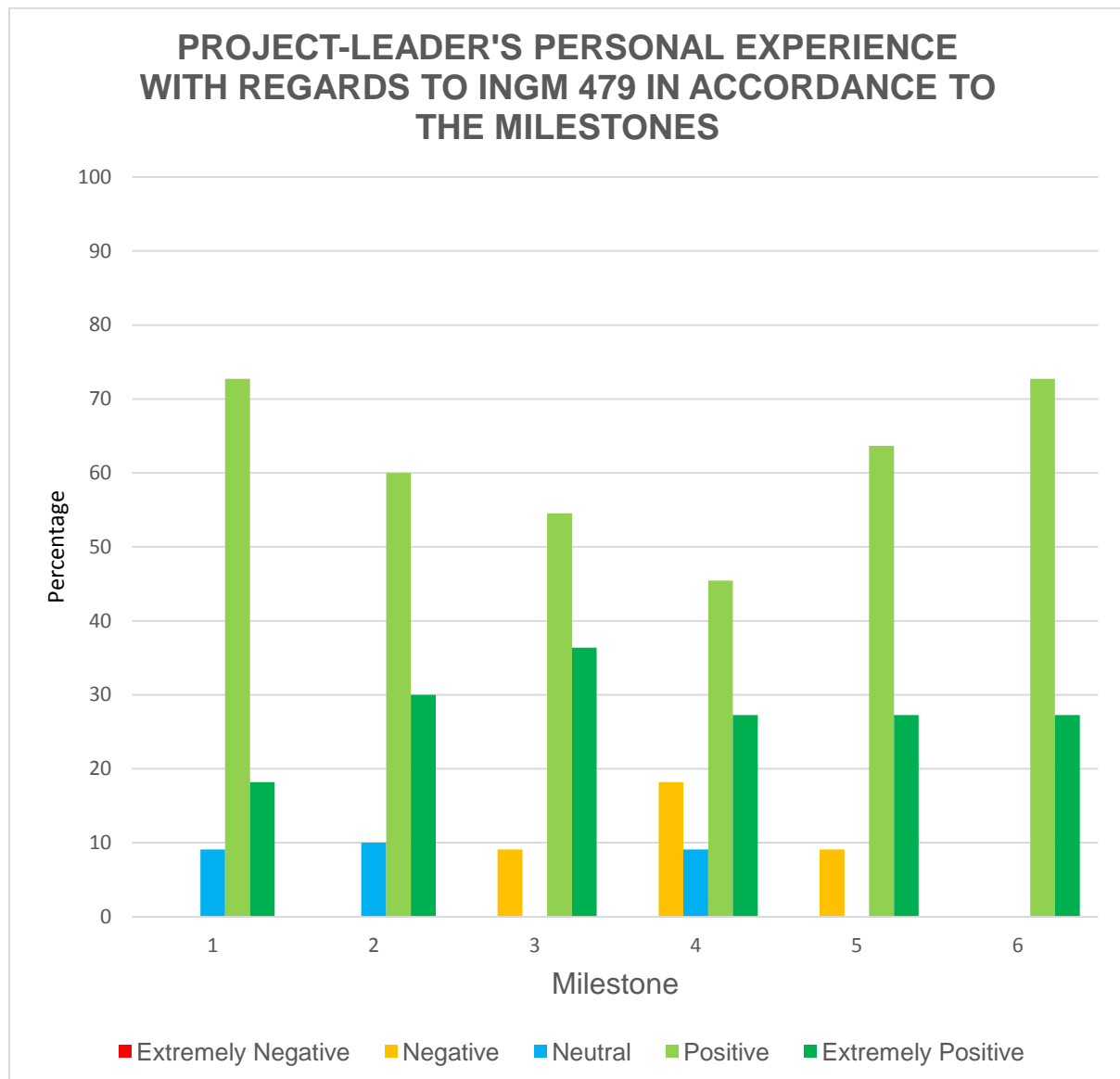


Graph 9: Preferred annual communication between Project-leaders and students

Graph 9 indicates the time intervals Project-leaders prefer in which to communicate with their Project students.

3.4 Project-leaders Personal Experience

With the increasing number of registered students and the static number of lecturers at the School of Mechanical and Nuclear Engineering each lecturer is subjected to an increasing workload. For moral implications due to the increasing pressure, the project-leaders were asked to indicate their personal experience towards INGM 479 with regards to each milestone. The information gathered can be used to address specific problems associated with each milestone. For survey refer to Appendix A.

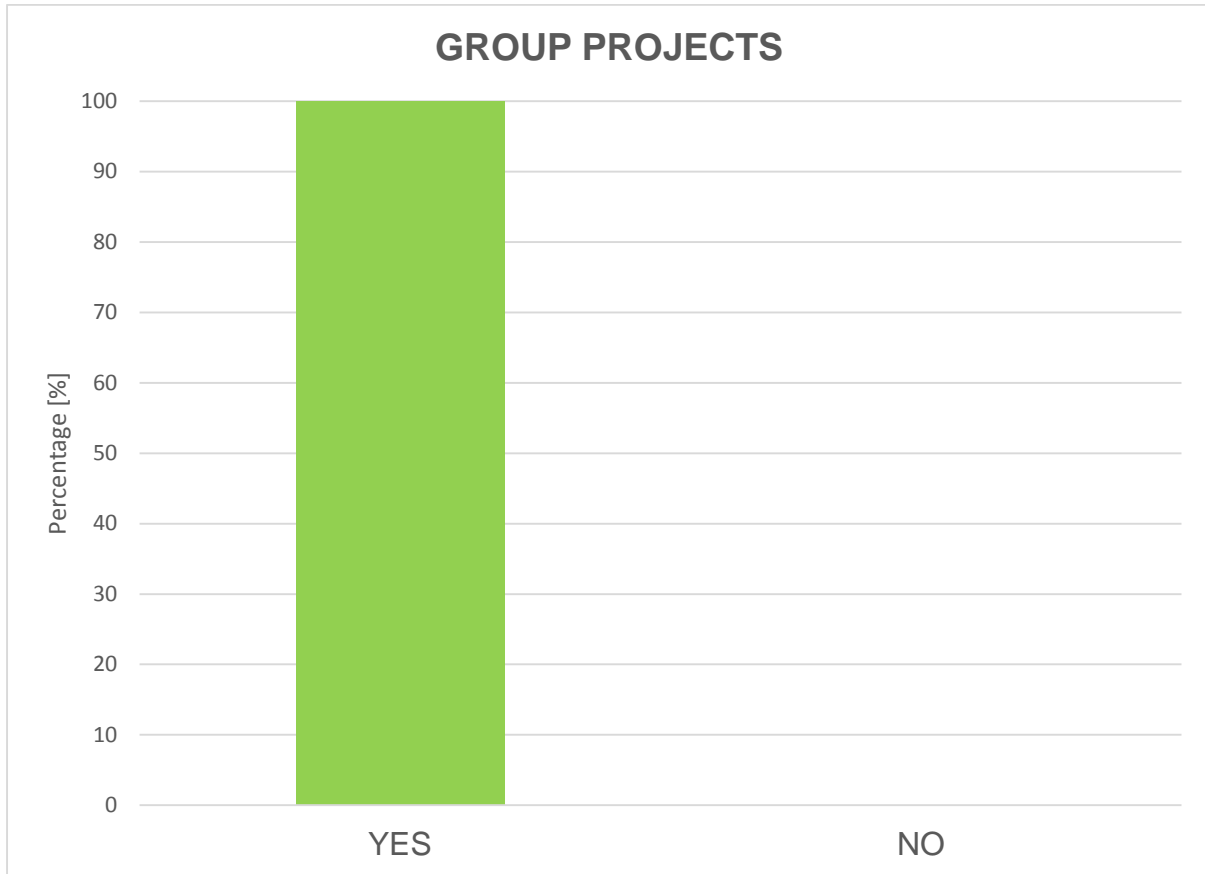


Graph 10: Project-leader's personal experience with regards to INGM 479 in accordance to the Milestones

Graph 10 indicates the personal feeling Project-leaders have towards INGM 479 with regards to the Milestones. The graph indicates that Milestone 3, 4 and 5 experienced some problems. Further research indicates that the problems associated with these Milestones are design based.

3.5 Group Projects

From the literature it can be seen that most Academic institutes implement group projects however the School for Mechanical and Nuclear Engineering only implement individual projects. Question 9 of the survey is used to determine the probability to implement group projects.



Graph 11: Implementation of Group Projects for INGM 479

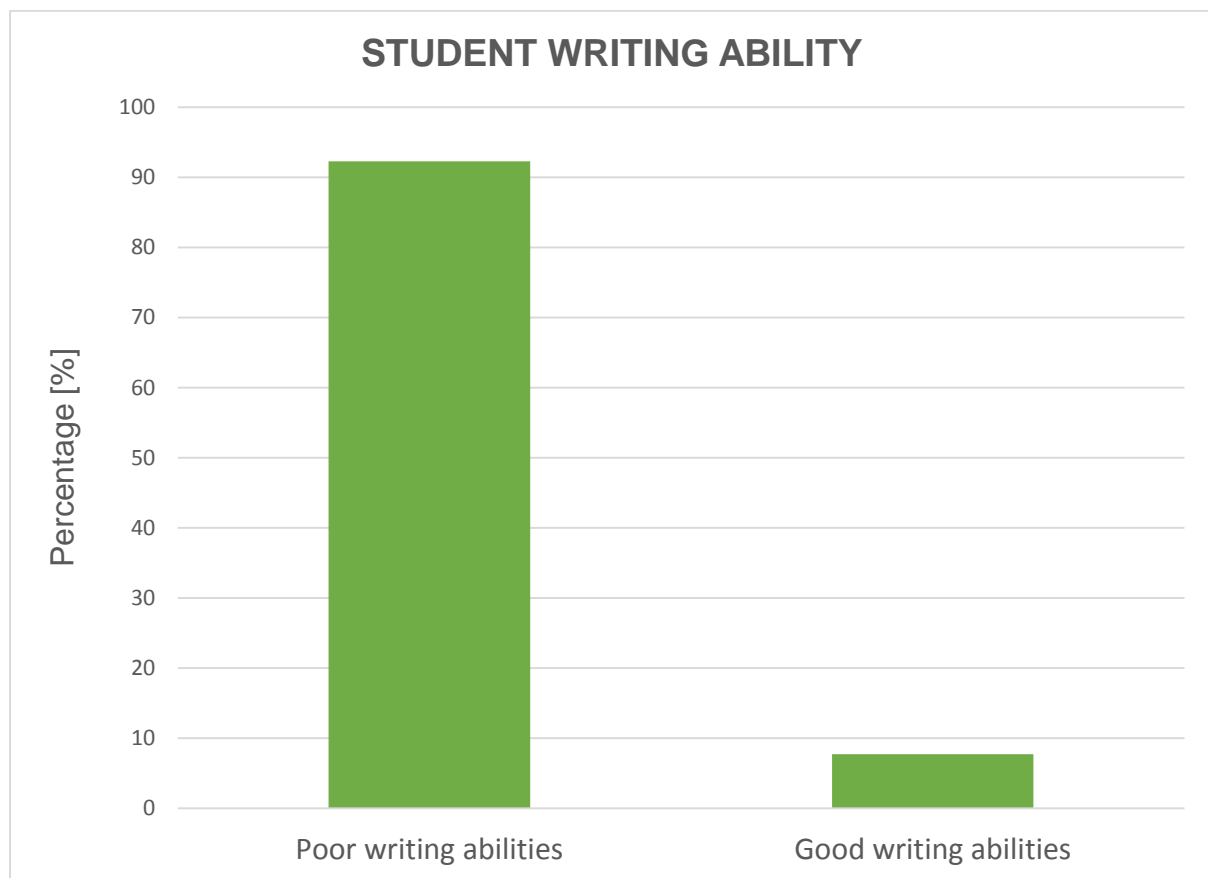
Graph 11 indicates the probability of implementing group projects for INGM 479.

3.6 Student INGM 479 Reports

From interviews with selected lecturers a problem arose and it was concluded that students report writing abilities seem to be inadequate. The selected panel of lecturers were chosen based to their academic background. They have more than 10 years' experience as project leaders and so have the necessary experience to evaluate the report writing abilities of students. From this, Question 10 of the survey is used to determine the overall indication of students report writing abilities.

All information for student INGM 479 Report was obtained from Survey (refer to Appendix F)

3.6.1 Student's Writing Abilities



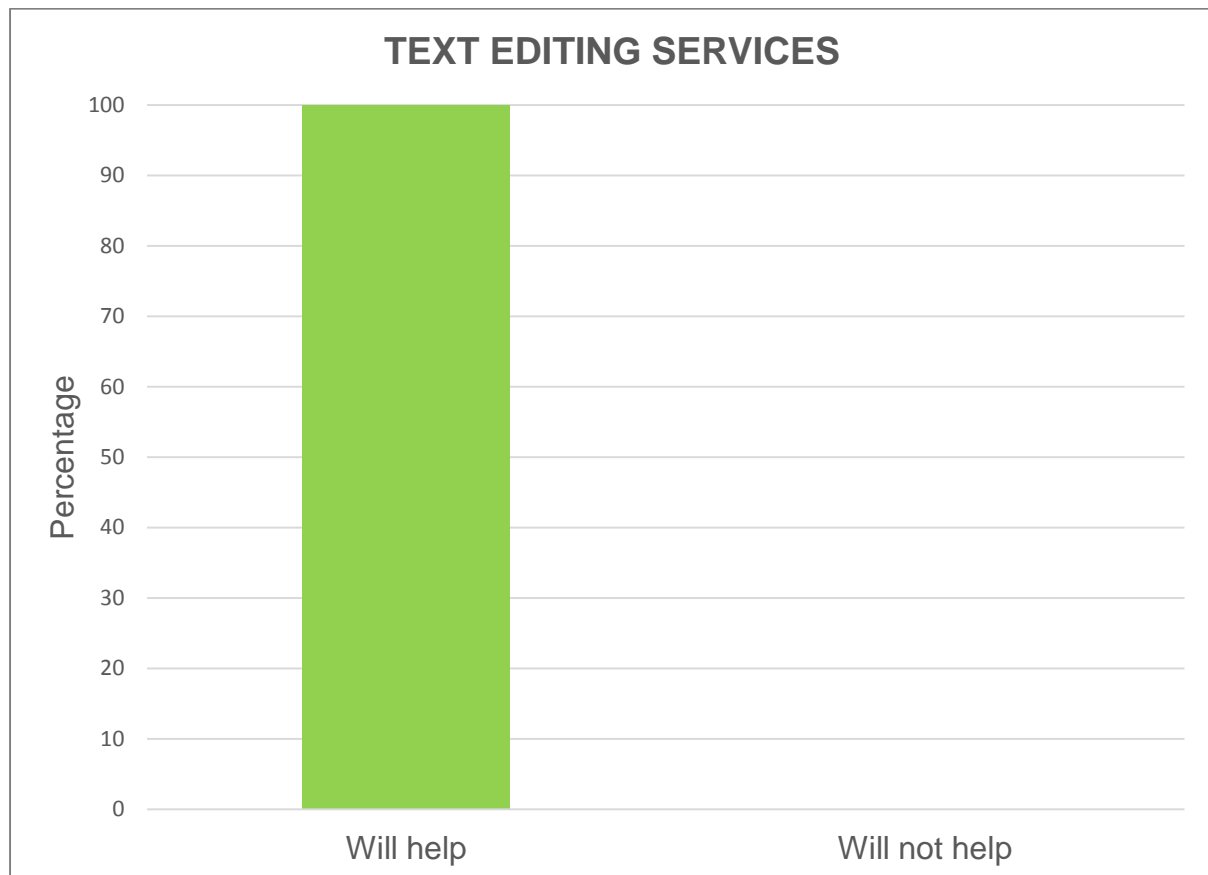
Graph 12: Student's Report Writing Abilities

Graph 12 indicates the Project-leaders opinion on students report writing abilities.

From this, further research indicated that the majority of time spend by Project-leaders on project related work is due to student report restructuring and improvement refer to Table 15 Milestone 5.

3.6.2 Text Editing Services

As a possible solution to the strain on lecturers, text editing services can be implemented to review reports before they are presented to project-leaders. This will minimize the time that project-leaders have to spend on restructuring and improving student reports. Question 11 of the survey is designed to determine the possibility of implementing text editing services.



Graph 13: Project-leader’s Personal opinion on the implementation of text editing services for student’s report

Graph 13 indicates the personal opinions of project leaders with regards to the implementation of text editing services for student’s project reports.

3.7 Implementation of Text Editing Services

For the calculation of the impact of implementing text editing services, a second survey (Survey 2.0) (for survey refer to Appendix B) was conducted and send to Project-leaders. From Survey 2.0, information with regards to the average number of hours each Project-leader spends on reading each report was obtained as well as the number of pages of reports for Milestone 1, Milestone 2 and Milestone 5.

Table 24 contains the average number of pages for each report for Milestone 1, Milestone 2 and Milestone 5 per student. The information for the number of pages was obtained from Survey 2.0 (for the survey refer to Appendix F).

Table 24: Average number of pages for reports

Milestones	Average Number of Pages
Milestone 1	23.333
Milestone 2	28.333
Milestone 5	53.333

Table 25 indicates the average number of hours each Project-leader spends reading student Reports. The information for the number of pages was obtained from Survey 2.0 (for the survey refer to Appendix F).

Table 25: Average number of hours reading Reports

Milestones	Average number of hours reading Reports [h]
Milestone 1	1.25
Milestone 2	1.417
Milestone 5	1.25

Table 26 indicates the average reading speed of Project-leaders with regards to student's reports for Milestone 1, Milestone 2 and Milestone 5. The average reading speed was calculated with Equation 6.

Table 26: Average reading speed of Project-leaders

Milestones	Average reading speed [min/page]
Milestone 1	3.214
Milestone 2	3.1097561
Milestone 5	1.40625

From Survey 2.0 it was concluded that the problem with reports for INGM 479 was mainly constricted to Milestone 1 and Milestone 2. For Milestone 5 text editing of reports have already been implemented by students. Information obtained from Survey 2.0 with regards to

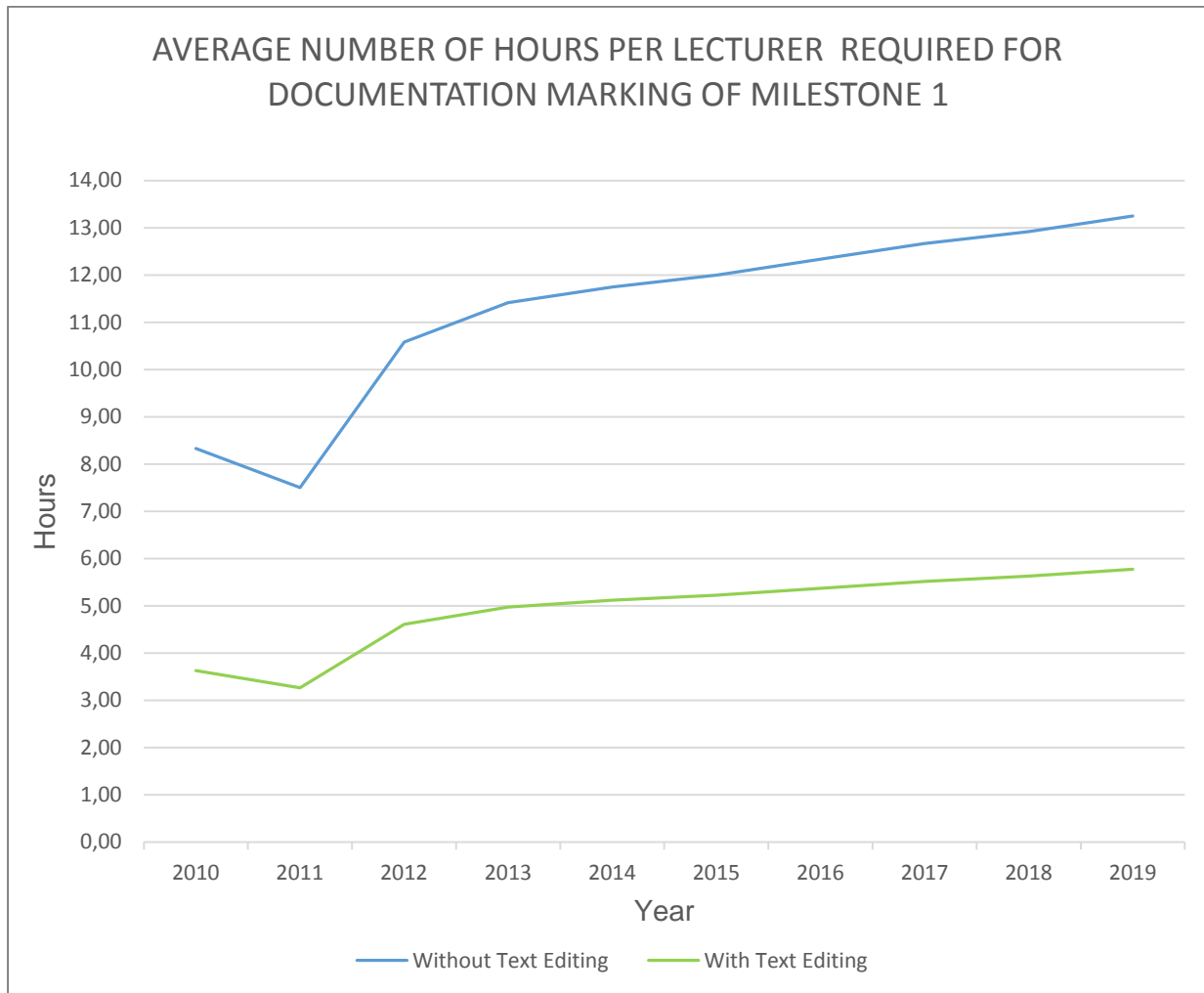
Milestone 5 was used to establish the average reading speed of Project-leaders when text editing for reports is already implemented. (For the survey refer to Appendix F)

3.7.1.1 Milestone 1

Table 27 indicates the average number of hours each Project-leader will spend reading all the reports for Milestone 1 for the number of registered fourth-year Mechanical Engineering students from 2010 till 2019. Table 27 also indicates the difference in time Project-leaders will spend reading reports which have not been text edited and reports which have been text edited. The average time difference is 6.36h.

Table 27: Average number of hours per Project-leader for reports for Milestone 1

Year	Average number of hours per Project-leader [h]		
	Before Text Editing	After Text Editing	Difference
2010	8.33	3.63	4.7
2011	7.50	3.27	4.23
2012	10.58	4.61	5.97
2013	11.42	4.97	6.45
2014	11.75	5.12	6.63
2015	12	5.23	6.77
2016	12.33	5.37	6.96
2017	12.67	5.52	7.15
2018	12.92	5.63	7.29
2019	13.25	5.77	7.48



Graph 14: Average Number of Hours per Project-leader required for Report reading for Milestone 1

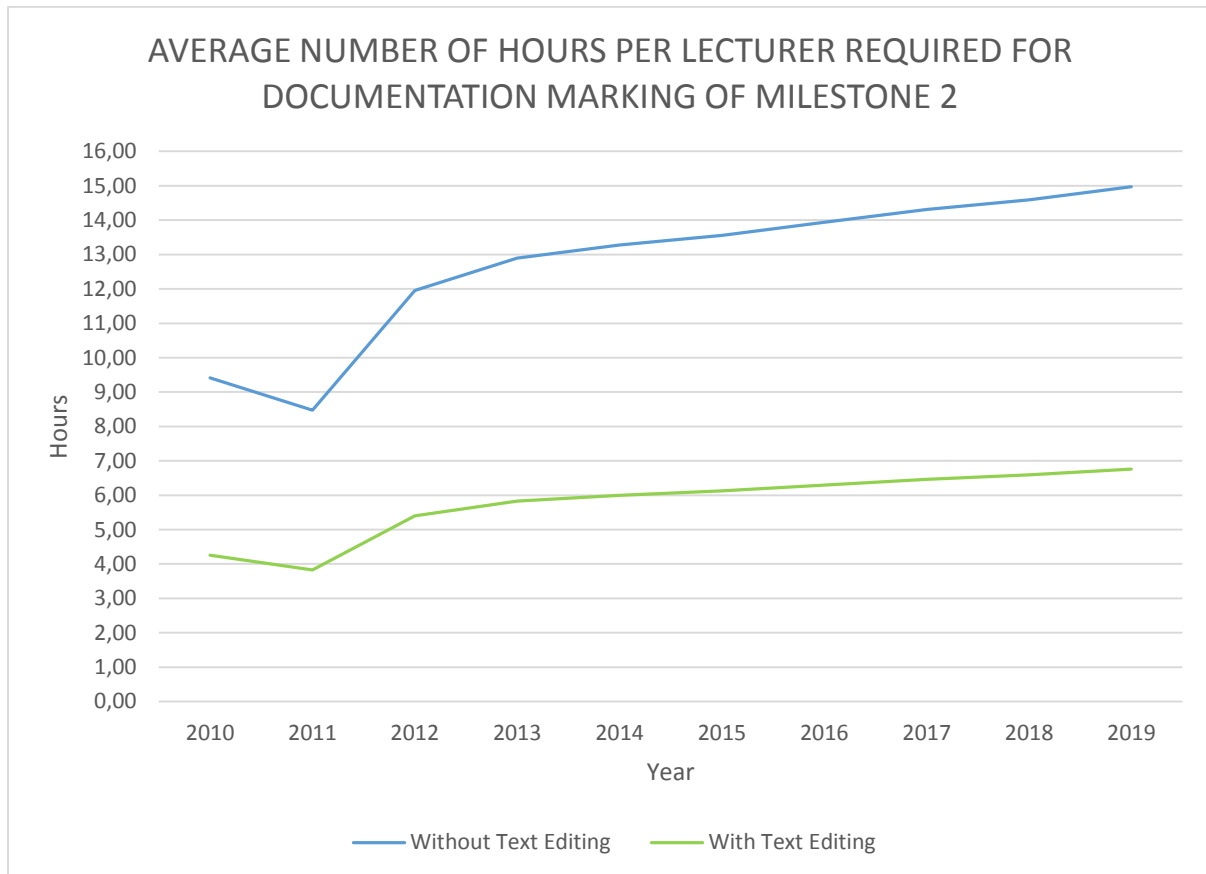
Graph 14 indicates the difference between the average number of hours each Project-leader will spend reading reports for Milestone 1 which have not been text edited and which have been text edited.

3.7.1.2 Milestone 2

Table 28 indicates the average number of hours each Project-leader will spend reading all the reports for Milestone 2 for the number of registered fourth-year Mechanical Engineering students from 2010 till 2019. Table 1 also indicates the difference in time Project-leaders will spend reading reports which have not been text edited and reports which have been text edited. Average difference is 6.986 h

Table 28: Average number of hours per Project-leader for reports for Milestone 2

Year	Average number of hours per Project-leader [h]		
	Before Text Editing	After Text Editing	After Text Editing
2010	9.41	4.25	5.16
2011	8.47	3.83	4.64
2012	11.96	5.40	6.56
2013	12.90	5.83	7.07
2014	13.27	6.00	7.27
2015	13.56	6.12	7.46
2016	13.93	6.29	7.64
2017	14.31	6.46	7.85
2018	14.59	6.59	8
2019	14.97	6.76	8.21



Graph 15: Average Number of Hours per Project-leader required for Report reading for Milestone

Graph 15 indicates the difference between the average number of hours each Project-leader will spend reading reports for Milestone 1 which have not been text edited and which have been text edited.

3.8 Available time for Project-leaders

The time each Project-leader will have available per student for Project-leader related work is calculated over a time period of nine years from 2010 till 2019.

For the calculations the number of workdays in one year for the North-West University, Potchefstroom campus, was calculated from the North-west University Calendar by comparing calendar years for 2009, 20010, 2012 and 2013.

Table 29 indicates the number of workdays for the North-West University, Potchefstroom campus.

Table 29: Workdays in one year

Total workdays in a year	Total work hours in a year	Total workweeks in a year
135 days	1080 hours	27 weeks

The calculations for determining the number of hours available for Project-leader related work per student per Project-leader is determined for 1-, 2- and 3 workdays per week. The calculations will only be considering the hours that project leaders will spend on project-leader related work.

Table 30 indicates the number of hours each Project-leader has available for Project-leader related work in one year. Hours are calculated by determining the number of hours available for the calendar year when only considering the number of hours when working 1-, 2- and 3-workdays. For Table 30 the number of hours available for Project-leader related work is calculated with Equation 7.

Table 30: Hours per year for Project-leader related work with regards to the number of Workdays in one week

Workdays for Project-leader related work	Hours for Project related work [h]
1 Workday	216
2 Workdays	432
3 Workdays	648

To determine the number of hours each project-leader spends on project-leader related work per day the number of students per project-leader is determined via question 6 of survey 1. The average number of project students per lecturer is then calculated and applied to the statistic prediction of registered students from Table 10.

Table 31 indicates the number of students per Project leader over a period of 10 years from 2010 till 2019. The number of students were determined with Equation 8.

Table 31: Number of students per Project-leader

Year	Number of students per Project-leader
2010	6.7
2011	6
2012	8.5
2013	9.1
2014	9.4
2015	9.6
2016	9.9
2017	10.1
2018	10.3
2019	10.6

3.8.1 One workday per week for Project-leader related work

To determine the number of hours each lecturer will have available for each student when it is assumed that each lecturer only devotes one workday per week on project-leader related work, the number of hours available per year for 1 workday a week from Table 30 is divided by the number of students over the time period from Table 31, refer to Equation 9.

Table 32 indicates the number of hours each Project-leader will have available per Student for one year when one workday per week is devoted to Project-leader related work. Calculations are based over a period of 10 years from 2010 till 2019.

Table 32: Number of hours available in one year per student for one workday in a week.

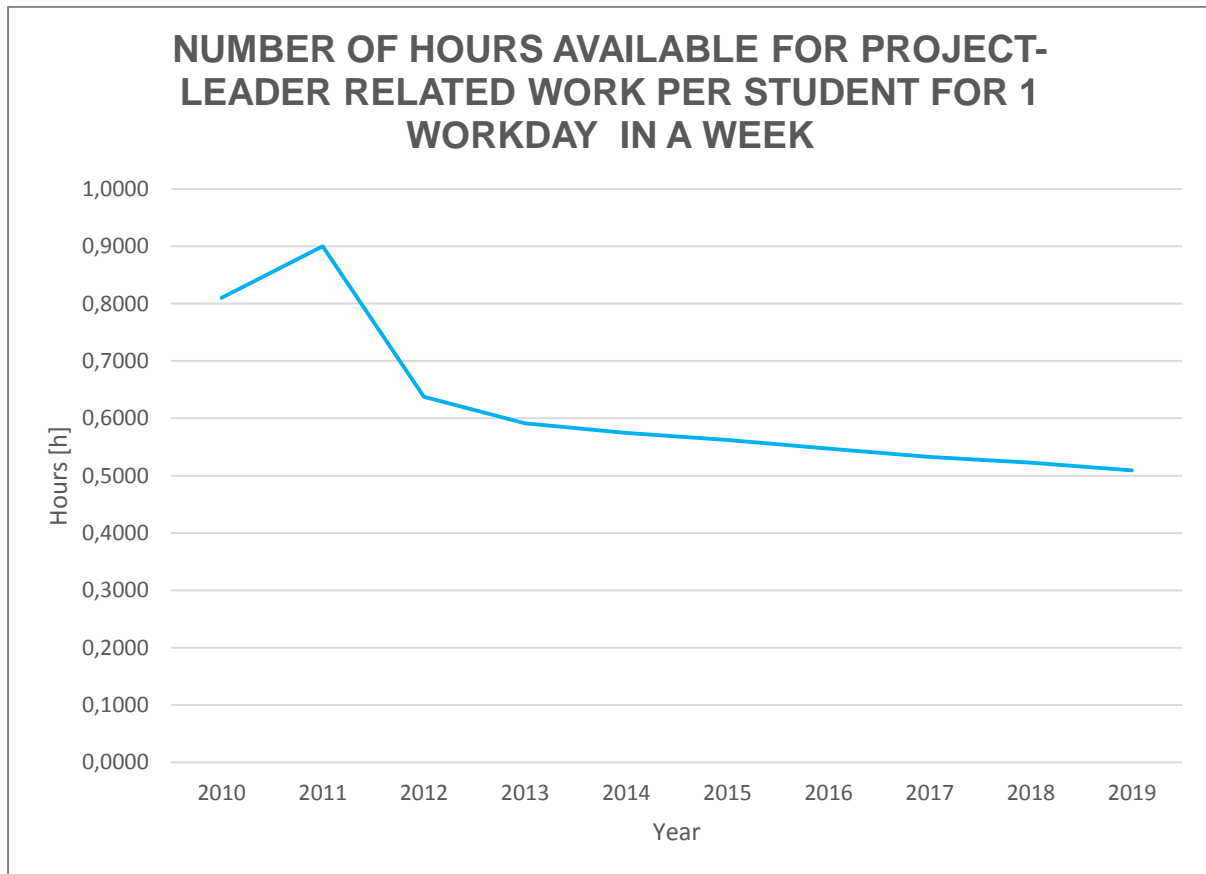
Year	Hours available per student in one year [h]
2010	32.4
2011	36
2012	25.51
2013	23.65
2014	22.98
2015	22.50
2016	21.89

2017	21.32
2018	20.9
2019	20.38

Table 33 indicates the number of hours each Project-leader will have available per Student in a week when one workday per week is devoted to Project-leader related work. The available hours is determined with Equation 10. Calculations are based on a period of 10 years from 2010 till 2019.

Table 33: Number of hours available in one week per student for one Workday in a week

Year	Hours available per student in one week [h]
2010	0.81
2011	0.9
2012	0.6378
2013	0.59.12
2014	0.5745
2015	0.5625
2016	0.5473
2017	0.5329
2018	0.5226
2019	0.5094



Graph 16: Number of available hours for Project-leader related work per student for one workday in a week

Graph 16 indicates the number of hours each Project-leader will have available per student per week when one workday per week is devoted to Project-leader related work. Calculations are based over a period of 10 years from 2010 till 2019.

3.8.2 Two workdays per week for Project-leader related work

To determine the number of hours each lecturer will have available for each student when it is assumed that each lecturer only devotes 2 workdays per week on project-leader related work, the number of hours available per year for 2 workdays a week from Table 30 is divided by the number of students over the time period from Table 31, refer to Equation 9.

Table 34 indicates the number of hours each Project-leader will have available per student for one year when two workdays per week is devoted to Project-leader related work. Calculations are based on a period of 10 years from 2010 till 2019.

Table 34: Number of hours available in one year per student for two workdays in a week

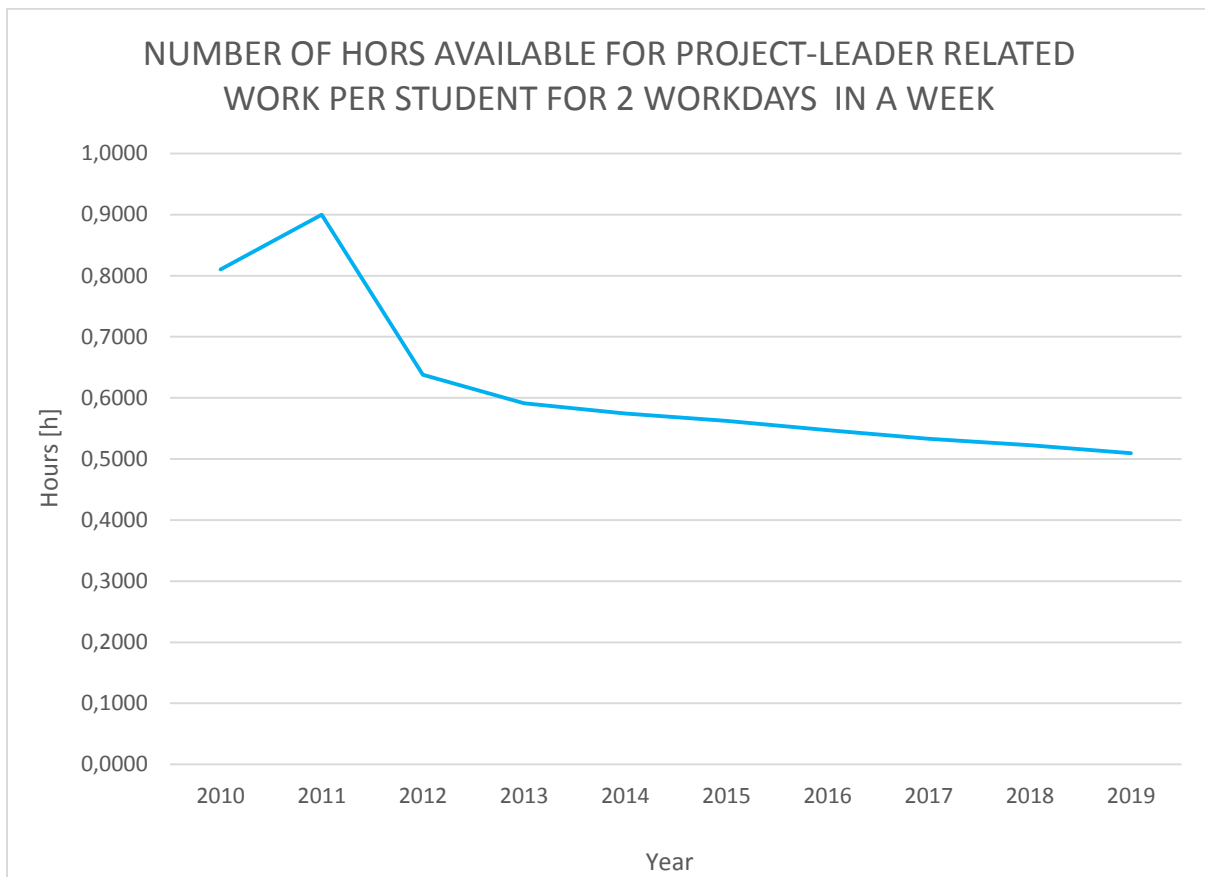
Year	Hours available per student [h]
2010	64.8
2011	72
2012	51.02
2013	47.3
2014	45.96
2015	45
2016	43.78
2017	42.63
2018	41.81
2019	40.75

Table 35 indicates the number of hours each Project-leader will have available per student per week when two workdays per week is devoted to Project-leader related work. The available hours are determined with Equation 10. Calculations are based on a period of 10 years from 2010 till 2019.

Table 35: Number of hours available in one week per student for two Workdays in a week

Year	Hours available per student in one week [h]
2010	1.62
2011	1.80
2012	1.28
2013	1.18

2014	1.15
2015	1.13
2016	1.09
2017	1.07
2018	1.05
2019	1.02



Graph 17: Number of available hours for Project-leader related work per student for two workdays in a week

Graph 17 indicates the number of hours each Project-leader will have available per Student per week when 2 workdays per week is devoted to Project-leader related work. Calculations are based on a period of 10 years from 2010 till 2019.

3.8.3 Three workdays per week for Project-leader related work

To determine the number of hours each lecturer will have available for each student when it is assumed that each lecturer only devotes 3 workdays per week on project-leader related work, the number of hours available per year for 3 workdays a week from Table 29 is divided by the number of students over the time period from Table 30, refer to Equation 9.

Table 36 indicates the number of hours each Project-leader will have available per student per year when three workdays per week is devoted to Project-leader related work. Calculations are based over a period of 10 years from 2010 till 2019.

Table 36: Number of hours available in one year per student for three workdays in a week

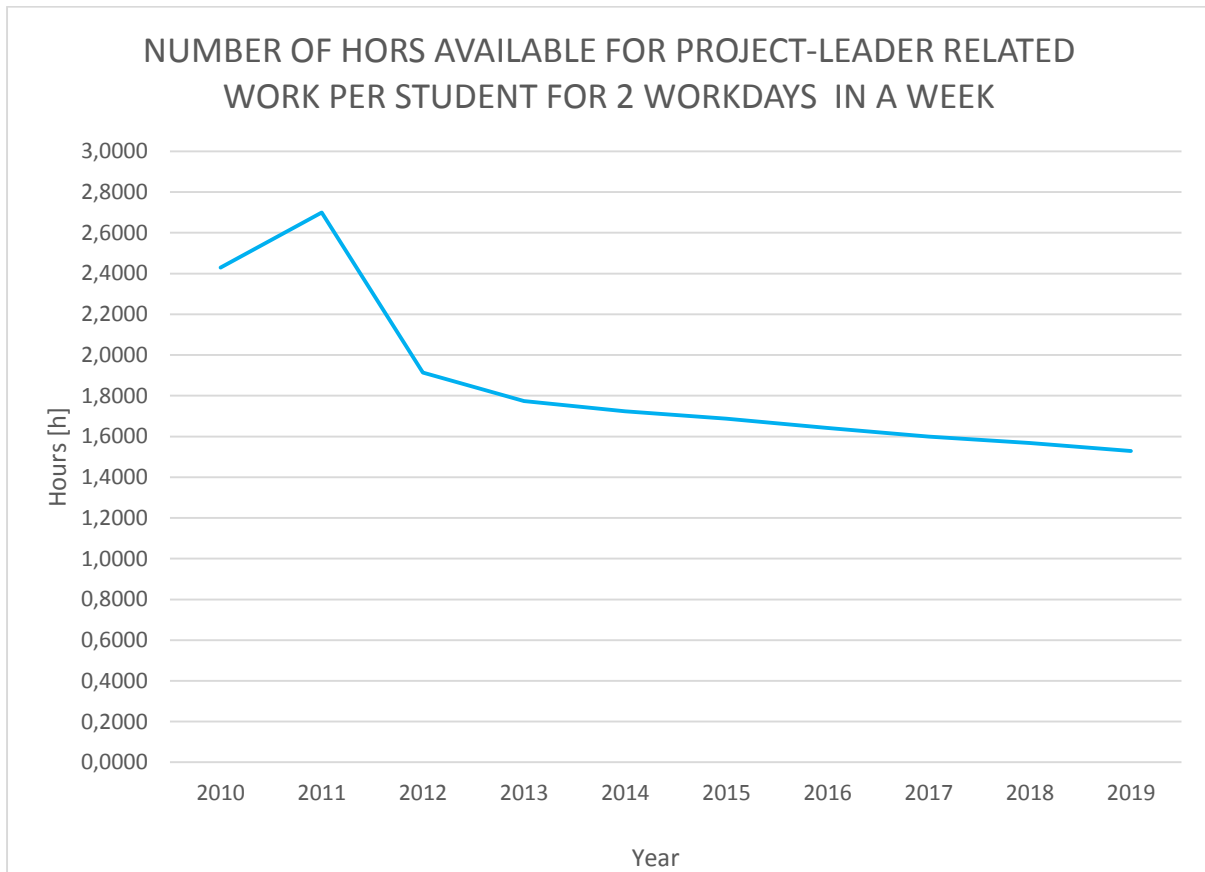
Year	Hours available per student [h]
2010	97.20
2011	108.00
2012	76.54
2013	70.95
2014	68.94
2015	67.50
2016	65.68
2017	63.95
2018	62.71
2019	61.13

Table 37 indicates the number of hours each Project-leader will have available per Student per week when three workdays per week is devoted to Project-leader related work. The available hours are determined with Equation 10. Calculations are based on a period of 10 years from 2010 till 2019.

Table 37: Number of hours available in one week per student for three Workdays in a week.

Year	Hours available per student in one week [h]
2010	2.43
2011	2.7
2012	1.9137
2013	1.7737

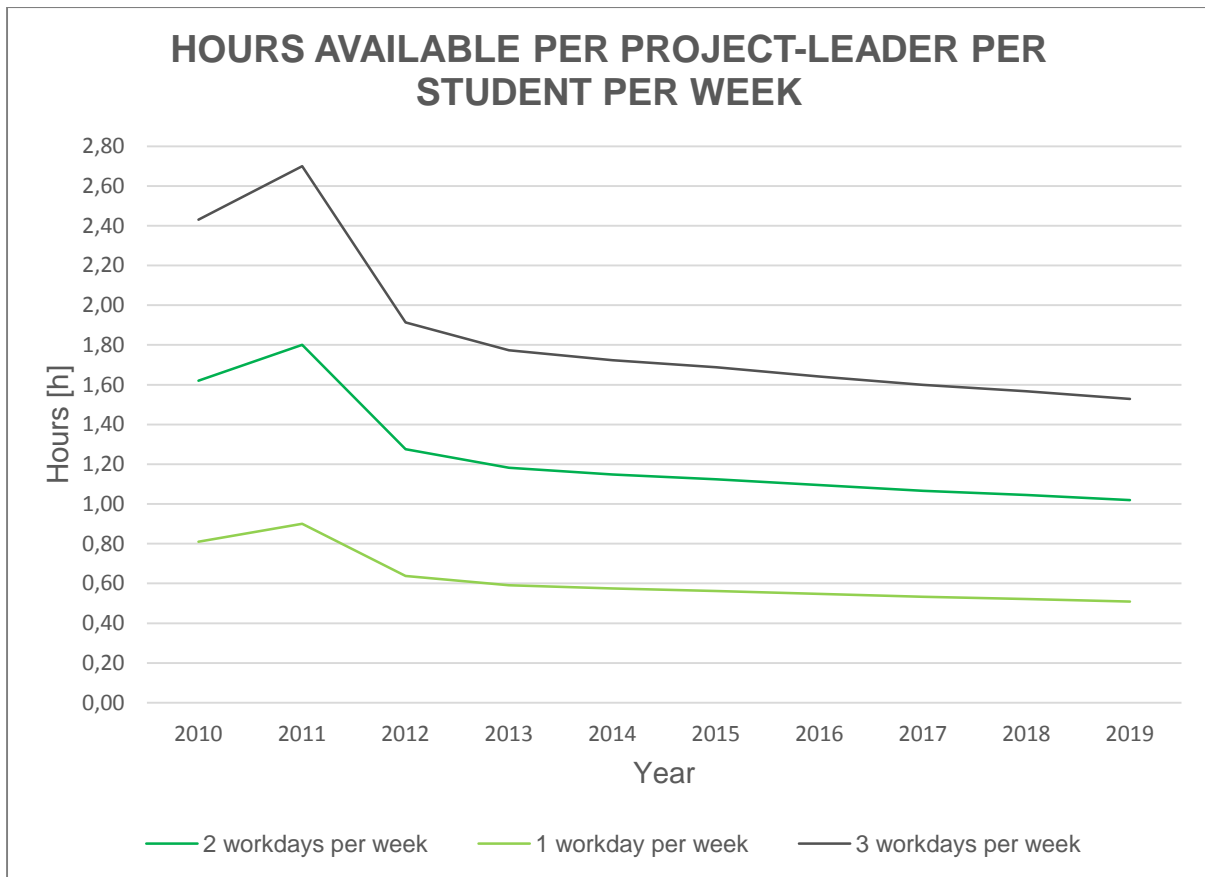
2014	1.7234
2015	1.6875
2016	1.6419
2017	1.5987
2018	1.5677
2019	1.5283



Graph 18: Number of available hours for Project-leader related work per student for three workdays in a week

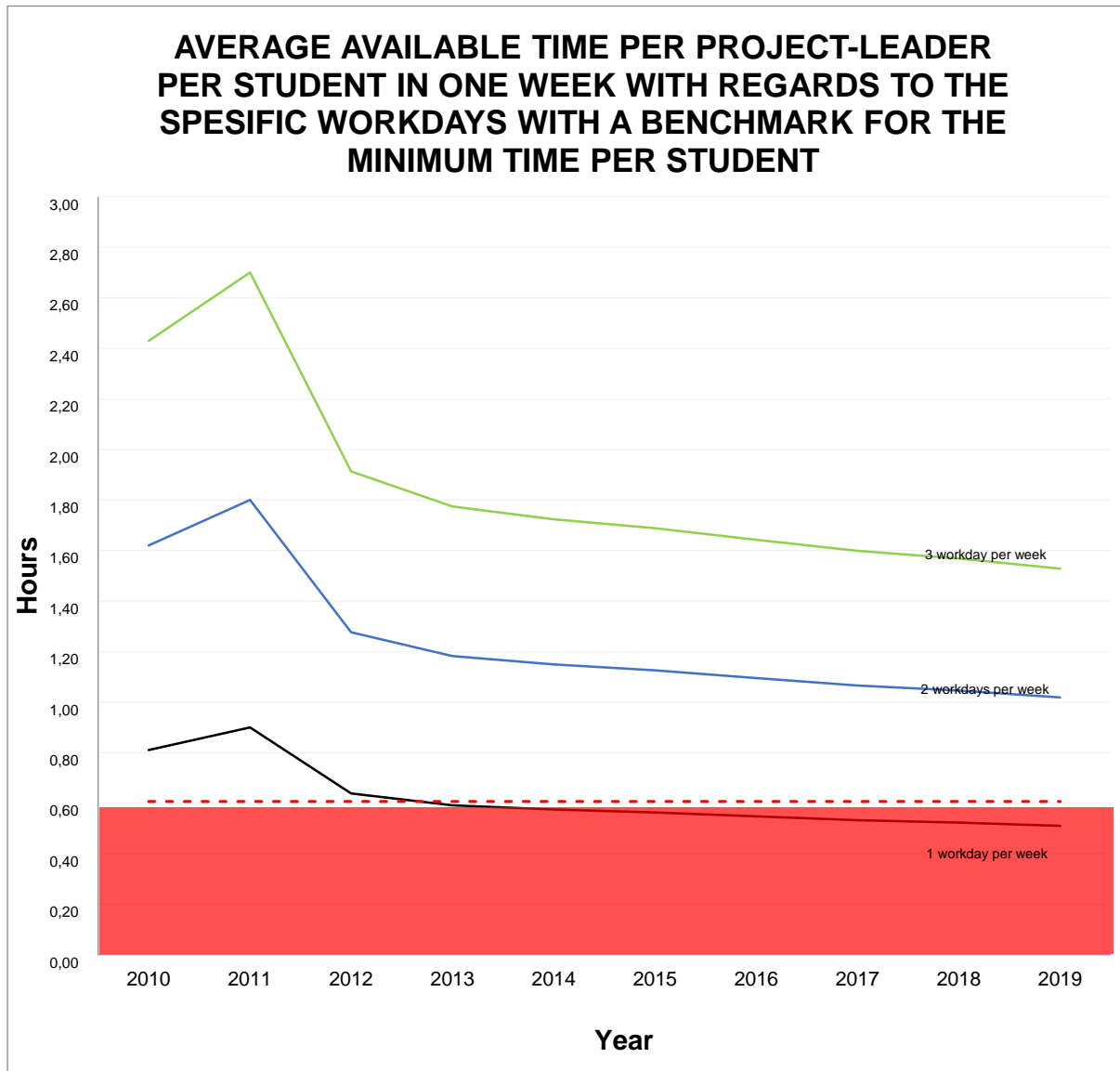
Graph 18 indicates the number of hours each Project-leader will have available per Student per week when 3 workdays per week is devoted to Project-leader related work. Calculations are based on period of 10 years from 2010 till 2019.

3.8.4 Available hours combination



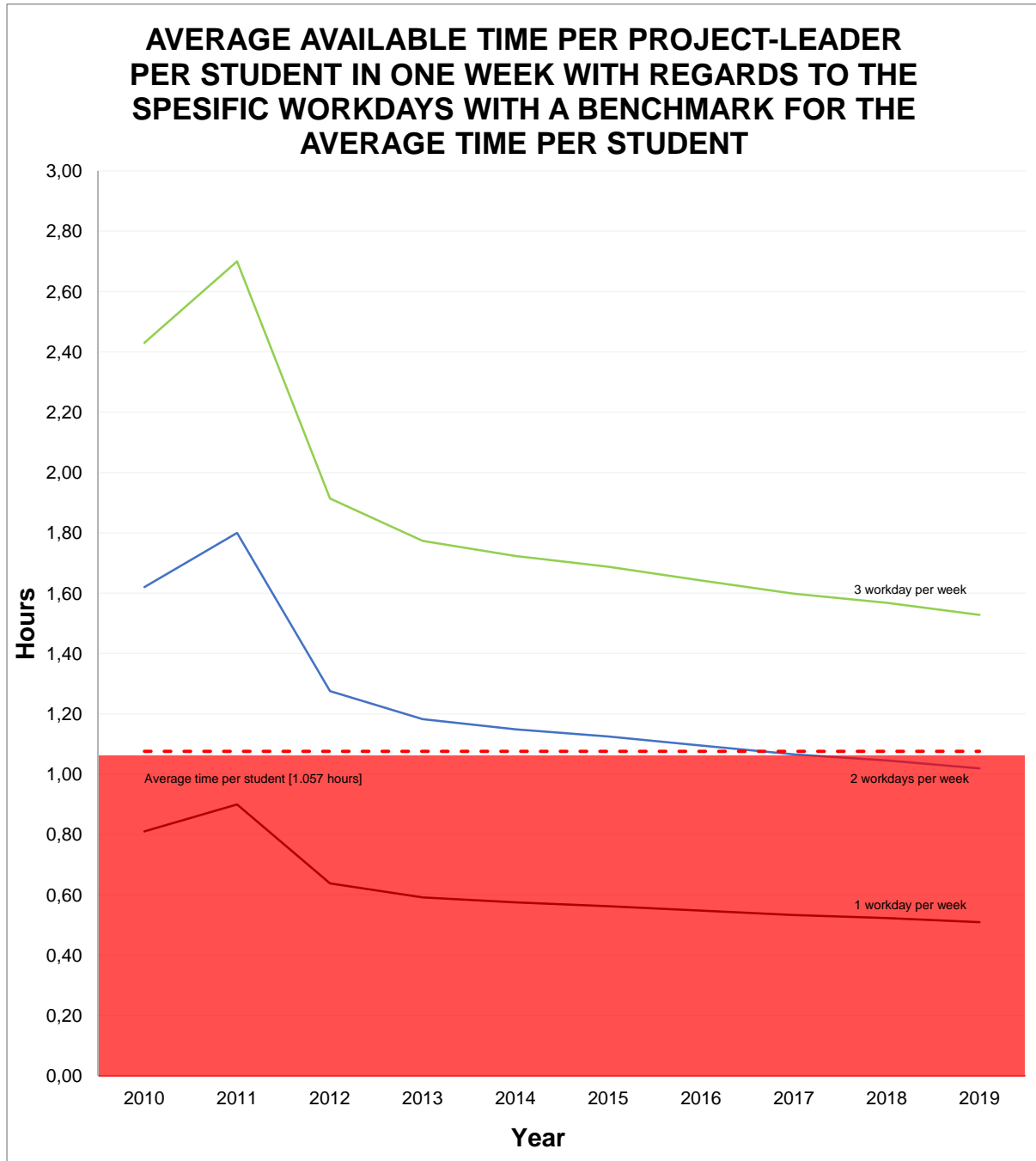
Graph 19: Hours available per Project-leader per student per week

Graph 19 indicates the available number of hours each Project-leader will have available to devote to each student per week with regards to 1 workday a week, 2 workdays a week and 3 workdays per week. Graph 19 is the combination of Graph 16, 7 and 18.



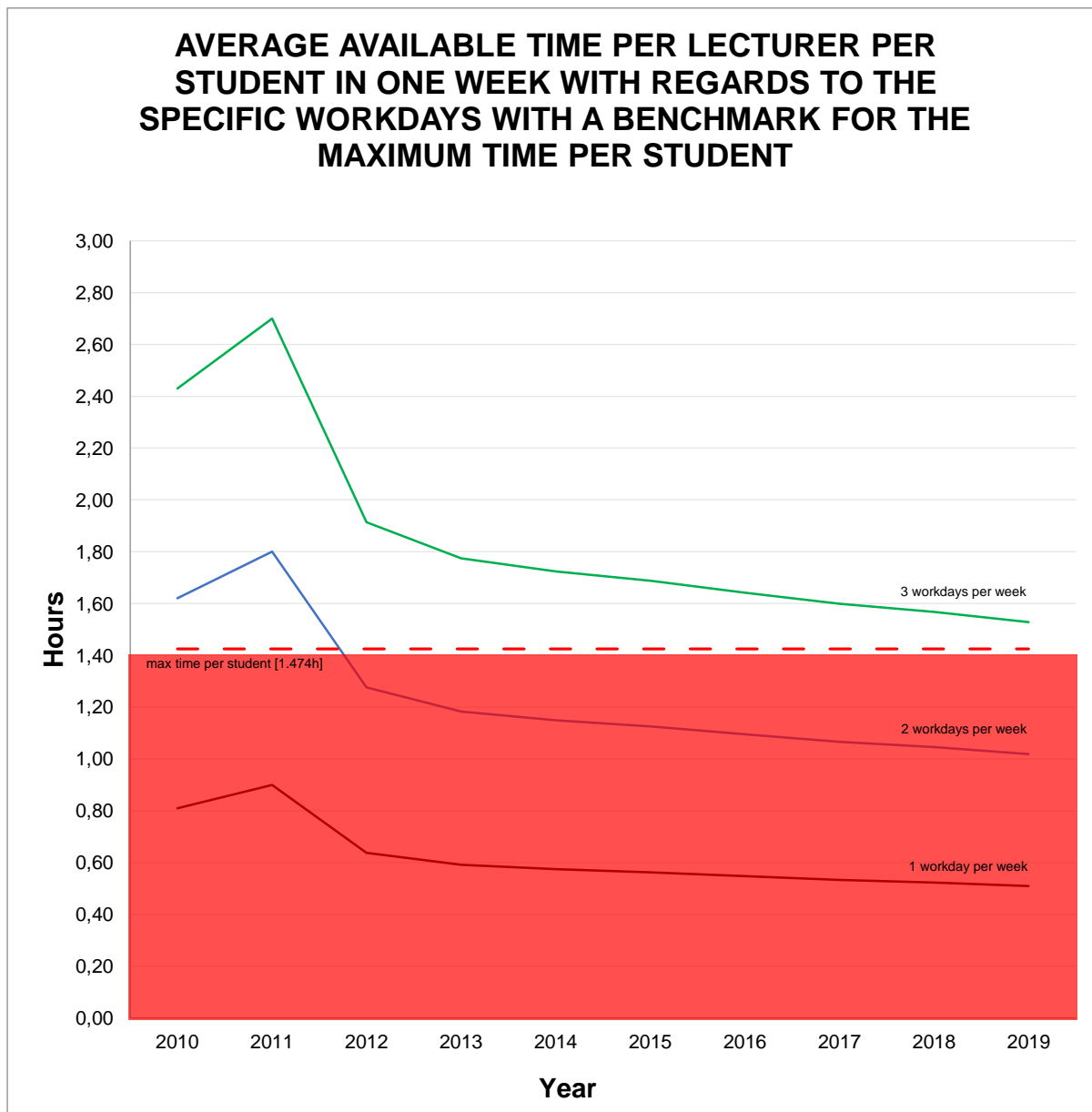
Graph 20: Average available time per Project-leader per student in one week with regards to the specific workdays with a benchmark for the minimum time per student

Graph 20 indicates the average time that each Project leader will have available in one week for Project-leader related work per student. The graph indicates the number of workdays each Project-leader must spend on Project-leader related work to be able to spend the minimum time of 0.6 h as indicated by survey Question 8 hours on Project-leader related work per Project student.



Graph 21: Average available time per Project-leader per student in one week with regards to specific workdays with a benchmark of the average time per student

Graph 21 indicates the average time that each Project leader will have available in one week for Project-leader related work per student. The graph indicates the number of workdays each Project-leader must spend on Project-leader related work to be able to spend the average time of 1.057 hours as determined by the survey question 8 on Project-leader related work per Project student.



Graph 22: Average available time per Project-leader per student in one week with regards to specific workdays with a benchmark of the maximum time per student

Graph 22 indicates the average time that each Project leader will have available in one week for Project-leader related work per student. The graph indicates the number of workdays each Project-leader must spend on Project-leader related work to be able to spend the maximum time of 1.474 hours as determined by the survey question 8 on Project-leader related work per Project student.

3.9 Project Management Structure

From the research, two structures are adequate to describe the management structure for a final year project. These structures include the Programmatic based management structure and the Matrix based management structure. This combination allows projects to evolve with in the research fields of the department. By developing projects within the research fields, projects are able to utilise the knowledge of each speciality field thus ultimately contributing to the research field.

The combination of the management structures allows the structures to eliminate of minimise the disadvantages of each structure.

From the Programmatic structure:

- A clear line of authority is established thus focusing projects with in a specific research field.
- Project members are familiar with in each other, thus optimizing communication and distribution of information within each research field.
- This structure eliminates the ineffective communication line of the Matrix's based structure.

From the Matrix structure

- Specialists are utilised from each research field, thus optimising the success of each individual project within the research field.
- Effective allocation of resources within each research field.

This combination thus allows each project to develop on its own with contributions of other projects within the research field. By integrating Ph.D, Masters and Undergraduate projects less strain is imposed on faculty members. For Ph.D level depends on the outputs of Masters projects and Masters projects are dependent on the outputs of undergraduate projects. This line of dependants forces each qualification plane to take responsibility for projects and thus project members exchange information with each other and thus less strain is applied to faculty members.

Each project does however still has a faculty member present to ensure that projects remain focused.

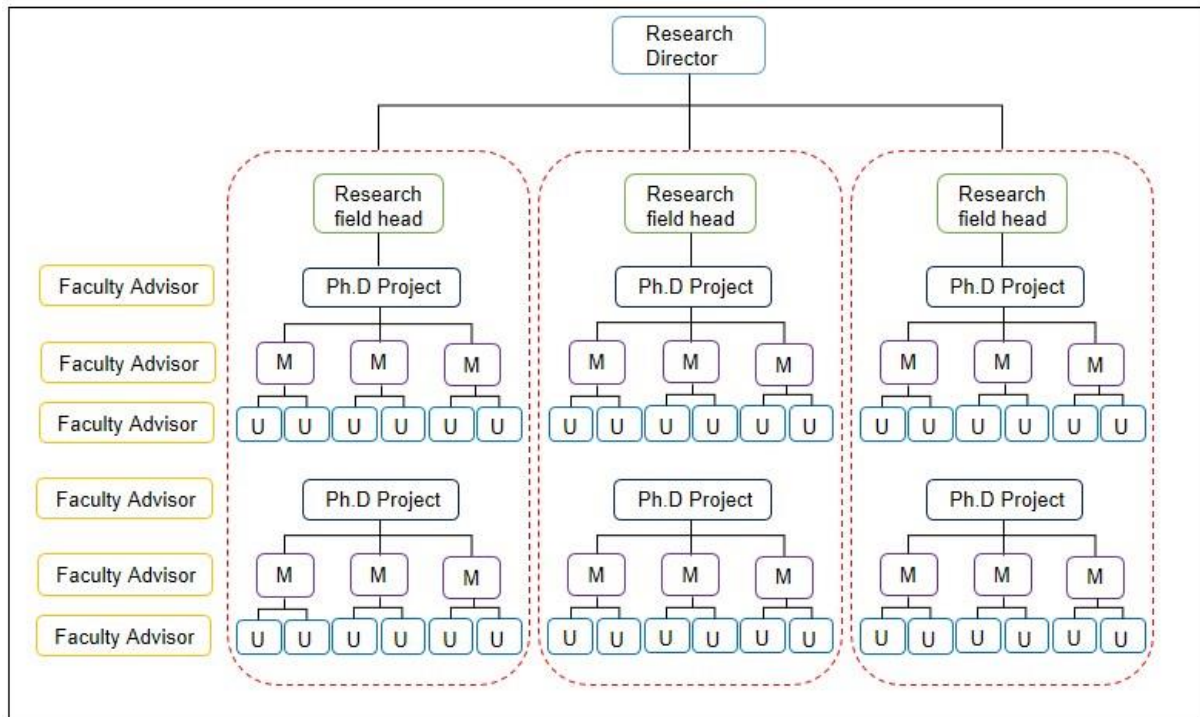


Figure 7: Combination Management Structure

Figure 7 indicates the Management structure for final year projects from the combination of the Programmatic Management structure and the Matrix based management structure.

Workshop Management Structure

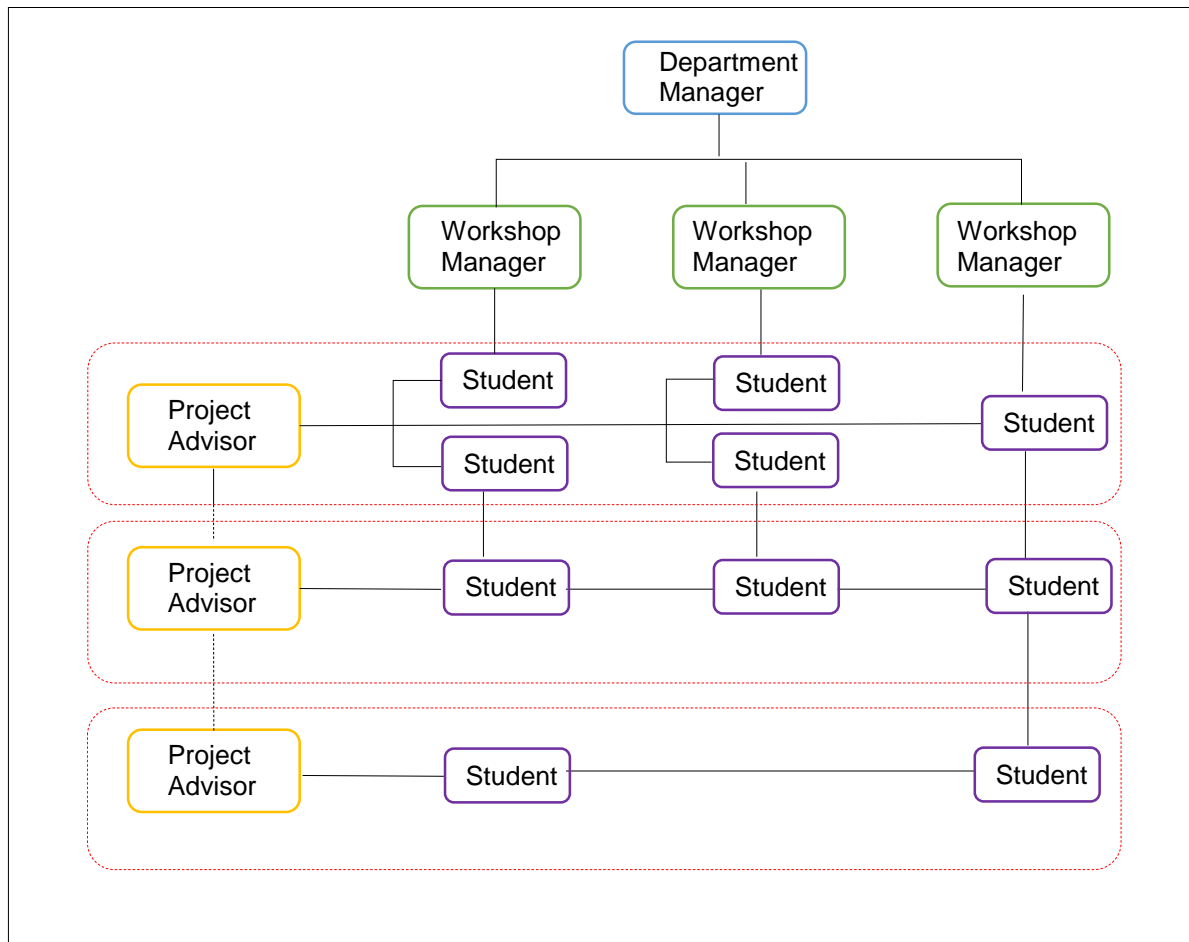


Figure 8: Workshop Management Structure

Figure 8 indicates the Management structure with regards to Academic Institution Workshops. This structure is based on the Matrix Based Organization structure. This is to ensure that resources are effectively distributed. The Department manager serves as the overall manager and workshop managers are responsible for their own workshops. Students are there for structured under a workshop manager and project advisor. This ensures that students are responsible for the construction of their own projects while project advisers provide guidance. This structure also represents industrial workshop structures. This then simulates an industrial environment and so prepares students for the working environment.

3.10 Project procedure

The project Procedure describes the different elements required to be able to successfully initiate a final year engineering project.

3.10.1 Project application

The project application includes the type of projects and project restrictions with regards to project selection by faculty advisors. By combining the information obtained from literature and

interviews with faculty advisors, the following aspects are considered as the most important for the selection of final year projects.

- Faculty advisors are responsible for obtaining projects.

Project selection:

- Projects must be within the research groups of the faculty.
- Projects must be within the knowledge capacity of students.

Project restrictions:

- Number of credits.
- Financial restrictions.
- Resources restrictions.

3.10.2 Project selection process

The project selection process includes the procedure to be followed by students for selecting final year projects.

Project selection process for students:

- Projects are listed according to faculty advisor academic field and within research groups.
- Students select three projects in preference from 1 to 3.
- Project selections form students are sent to the project committee.
- The project committee allocate projects to students.
- Project allocation procedure:
 - Project advisors' preference.
 - Students' preference.
 - Students' academic record.
- Students are informed of project allocations.

Project selection process by students:

- Listing all the project.
- Filter projects by considering long term goals.
- Filter the new set of projects by considering short term goals.
- Filter the new set of projects by considering the senior capstone course requirements.
- Filter the last set of projects by considering available resources.

- Resources include:
 - Time.
 - Money.
 - Technical knowledge.
- Select a project from the last filtered set of projects.

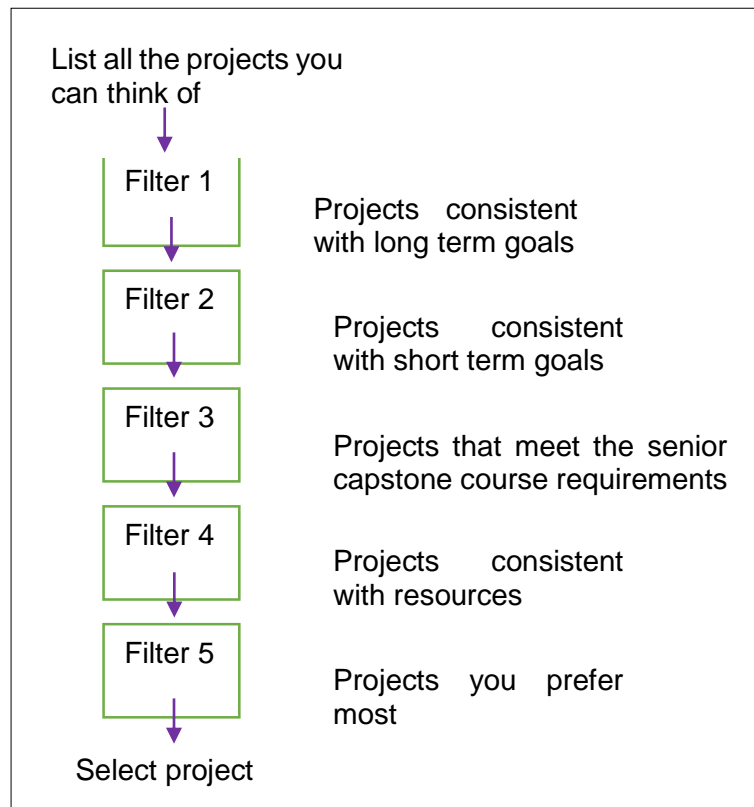


Figure 9: Project selection by students

Figure 9 indicates the project selection process for students.

(Bachnak and Copponger, 2005)

3.10.3 Project initiation

Project initiation for students:

From the literature Graph 1: capstone course sequence and structure indicates that formal class is preferred to introduce projects to students and guide students throughout the project.

Subjects should include topics as indicated in the literature in Table 3 as well as Report Writing.

Project initiation for project advisors:

From the literature and interviews conducted with current project advisors from the North-West University, University of Pretoria and Stellenbosch University the following objectives for project initiation are essential for the completion of a successful final year's project.

Before projects are presented to students project advisors must be able to complete the following SOW (for more information refer to Appendix D):

- Scope
- Background
- Vision
- Goal Statement
- Objectives
- Deliverables
- Assumptions
- Constraints

Projects must be so constructed that the end result is clearly defined and understood from the project initiation stage.

Projects must be constructed in such a way that they meet the objectives and outcomes as listed in table 12 as indicated by the literature.

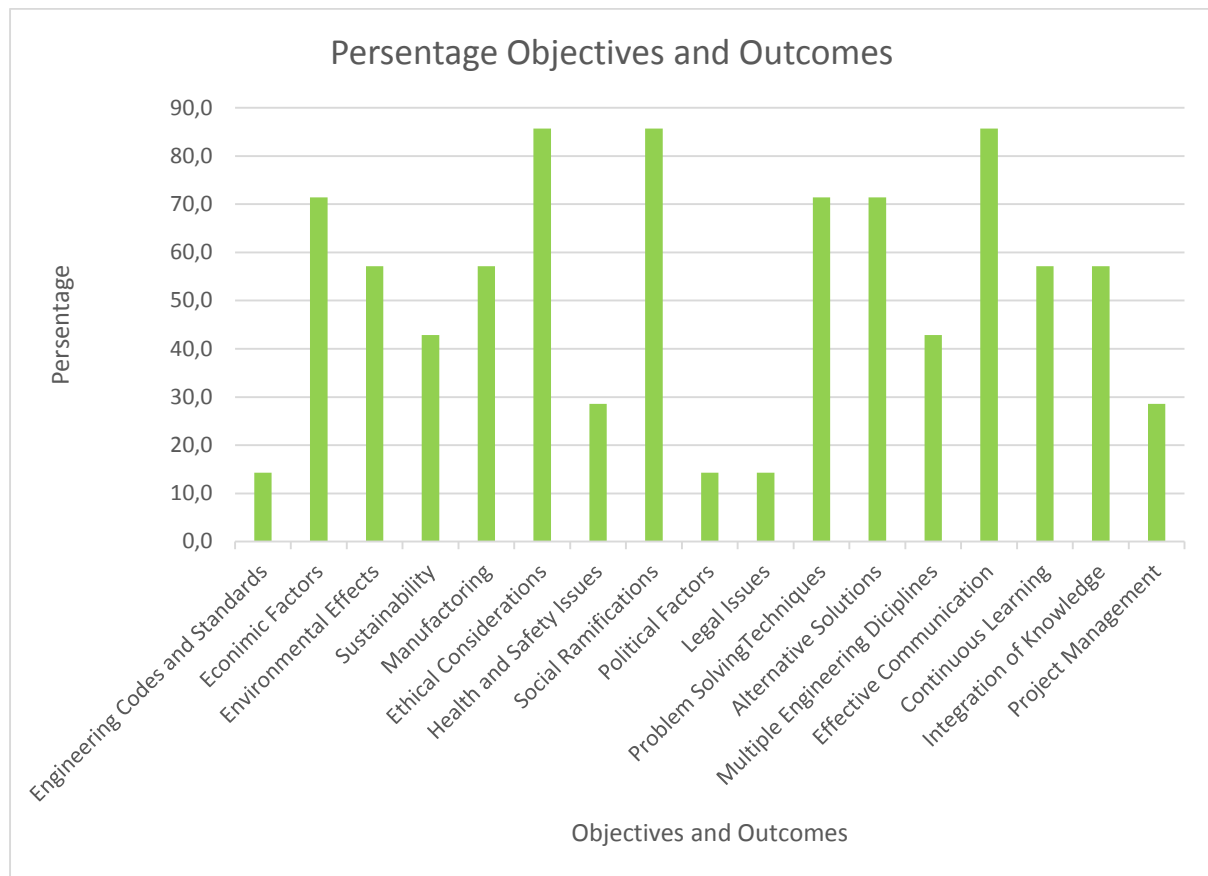


Figure 10: Objectives and Outcomes

Figure 10 indicates the percentage of importance of use by different sources for the specific objectives and outcomes required for the completion of final year projects.

3.10.4 Project monitoring

The Project-advisor is responsible for project monitoring. According to the research for project initiation the final outcome of all projects must be known in advance by the project advisor. (Refer to 2.3.4 Project description for final year’s projects pg. 16) With this an approximate Gantt-chart is required to evaluate the project progress.

Project Milestones are also a means to monitor projects. (Refer to Table1 School for Mechanical and Nuclear Engineering). Milestones require students to complete certain aspects of the project within a specific timeframe. This helps students by breaking up the project in specific divisions thus allowing students to focus on a small part of the project at a time. The progress of the project can then be asses in accordance with the Milestones.

3.10.5 Project evaluation

Table 38 indicates the Theoretical requirements that are necessary for the completion of a successful final year project according to the national survey in 2005 (Howe, 2010) and the Outcomes and Objectives of final year Engineering projects (Table 1). By comparing the two, the key aspects for final year projects are highlighted.

Table 38 Outcomes to be evaluated

National survey Theoretical requirements for completion of successful final year project	Table 2: outcomes and objectives of final year engineering projects
Engineering codes and standards	Engineering ethics Quality Function Development. Standard and Regulations
Economic factors	Engineering Economics
Environmental effects	
Sustainability	Sustainability
Manufacturing	Prototyping and Testing Manufacturing Processes
Ethical considerations	
Health and safety issues	Safety in Project Design
Social ramifications	
Political factors	
Legal issues	Intellectual Property
Problem solving techniques	CAD Design and Layout Analysis Tools Prototyping and Testing
Alternative solutions	Decision-Making Risk Assessment
Multiple engineering disciplines	Team Dynamics Teambuilding
Effective Communication	Drawing, Creativity or Concept or Generation Writing Abilities Drawing, Creativity or Concept or Generation
Continuous Learning	
Integration of Knowledge	
Project Management	Leadership Project Planning and Scheduling
	Optimization
Refer to Theoretical requirements for the completion of a successful final year	Refer to Table 2 pg. 32

project according to the national survey in 2005 includes: (Howe, 2010) pg. 34	
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Table 38 concludes that the aspects that need to be addressed for evaluation is:

- Engineering Codes and Standards
- Economic factors
- Sustainability
- Manufacturing
- Health and Safety
- Legal issues
- Analysis tools
- Alternative solutions
- Team Dynamics
- Communication
- Project Management

This concludes that if a student proves that they have addressed these aspects successfully that the project is successfully completed.

Project presentation is a useful way to evaluate projects according to Gnanapragasam (2008). Project presentation is the final evaluation for projects. This simulates the environment of a conference and thus allows students the experience.

Table 39 indicates different assessment tools to evaluate the program outcomes. Refer to Table 8.

Table 39 Assessment tools for evaluating project-outcomes

Fundamentals	Performance by student
Design	Evaluation of final reports Responses of sponsor surveys
Teamwork	End of the quarter peer review and faculty evaluation
Problem solving	Evaluation of final reports
Communication	Evaluation of oral presentations, proposals, and reports

4 Findings

Key findings include:

4.1 Faculty advisor

A Faculty advisor is assigned to every project.

Requirement for faculty advisor concludes that a faculty advisor must:

- Be a practising engineer.
- Have experience and practice in the particular field of the project.
- Provide guidance and counselling to students.

Work description for the faculty advisor concludes that a faculty advisor must:

- Select and develop projects.
- Have prior knowledge of the project outcomes.
- Review all document before presenting it to the industry liaison for industry sponsor projects.

Survey results:

- Communication: The most preferred method of communication that is used between Project- leaders and Students according to graph 8 is weekly Group meetings.
- Most problematic Milestones: According to Graph 10 the Milestones that result in the most negative feedback is Milestone 3, 4 and 5. Further research indicates that the problems associated with these Milestones are design based.
- Group projects: Graph 11 indicates that all Project-leaders are willing to implement group projects.
- Writing abilities: Students present poor report writing abilities which also contributes to the high number of hours that each project-leaders must spend on project-leader related work.
- Text Editing Services: Graph 13 indicates that 100% of project-leaders are willing to implement Text Editing Services for student reports.

4.2 Faculty Advisor Time frame

From Graph 3, it can be seen that there is an increase of student registrations with a trend with gradient 6.81. With this increase the strain on project-leaders increases. According to Graph 7 the maximum number of hours that each project-leader must spend on project-leader related work each day is 3 hours, thus concludes that project-leaders only have 5 hours per day for faculty member work.

Graph 20 concludes that Project-leaders must spend 2 to 3 workdays a week only on project-leader related work, with the increasing number of registrations, if they want to spend the minimum of 0.6 h (as indicated by the survey) per student.

Graph 21, concludes that Project-leaders must spend 2 to 3 workdays a week from 2010 till 2017 and 3 workdays a week from 2017 only on project-leader related work, with the increasing number of registrations, if they want to spend the average of 1.057 h (as indicated by the survey) per student.

Graph 22, concludes that Project-leaders must spend 3 workdays a week only on project-leader related work, with the increasing number of registrations, if they want to spend the maximum of 1.474 h (as indicated by the survey) per student.

This concludes that Project leaders must spend approximately 2 workdays a week on project-leader related work with the increasing number of registrations. This limits the available time in a week to be able to focus on faculty member related work. If Project leaders spend less time than the minimum number of hours on each student and thus devote less than 2 days on project-leader related work students will then be negatively affected.

Implementation of Text Editing Services

Graph 14 concludes that the implementation of text editing services will decrease the number of hours that each project-leader spend on rectifying student reports and thus on the average number of time spend on project-leader related work. The Average time difference between reports that have not been text edited and those that have for Milestone 1 and 2 is 6.673h thus with the implementation of text editing the project-leaders save an average time of 13.346 hours for Milestone 1 and Milestone 2 over 10 years from 2010 till 2019. Refer to Table 25 and Table 26 as well as Graph 13 and Graph 14. Text editing services will not be implemented for the final report, with the implementation of text editing services for Milestone 1 and 2 the main problem of poor reports is already rectified.

4.3 Project Selection

Projects must be:

- Within the research groups of the faculty.
- Within the knowledge capacity of students.

Restrictions on the type and size of a project are restricted by the:

- Number of credits devoted to the module in the curriculum. This directly influence the time that is to be devoted on the project by the students.
- Financial restrictions. This directly influenced by the source of the project, specifically Industrial or departmental.
- Resources restrictions. This is directly influenced by the research groups that are established at the academic institution.

4.4 Project Procedure

Project initiation for students:

From the literature Graph 1: capstone course sequence and structure indicates that formal class is preferred to introduce projects to students and guide students throughout the project.

Subjects should include topics as indicated in the literature in Table 3

Before projects are presented to students project advisors must be able to complete the following SOW (refer to Appendix D for more information):

- Scope
- Background
- Vision
- Goal Statement
- Objectives
- Deliverables
- Assumptions
- Constraints

Projects must be constructed in such a way that the end result is clearly defined and understood from the project initiation stage.

Projects must be constructed that they meet the objectives and outcomes as listed in Table 12 in the literature.

Project Selection for students:

Project allocation procedure:

- Project advisors' preference
- Students preference
- Students' academic record

4.5 Project Outcomes and Objectives

Table 38 concludes that the outcomes that need to be addressed for evaluation are:

- Engineering Codes and Standards
- Economic factors
- Sustainability
- Manufacturing

- Health and Safety
- Legal issues
- Analysis tools
- Alternative solutions
- Team Dynamics
- Communication
- Project Management

4.6 Project logistics

Group projects must be implemented to minimize the time spend on project by project-leaders. Group projects also resemble the actual working conditions for engineers in the industry.

Advantages:

- Fosters innovation
- Economical
- Prepares students for the industry

Table 4 concludes that the number of students per group must be limited between 3 and 4 students per group.

4.7 Project Monitoring

The Project-advisor is responsible for project monitoring. According to the research for project initiation the final outcome of all projects must be known in advance by the project advisor. (Refer to 2.3.4 Project description for final year's projects pg. 16) With this an approximate Gantt-chart is required to evaluate the project progress.

Project Milestones are also a means to monitor projects. (Refer to Table1 School for Mechanical and Nuclear Engineering). Milestones require students to complete certain aspects of the project within a specific timeframe. This helps students by breaking up the project in specific divisions thus allowing students to focus on a small part of the project at a time. The progress of the project can then be asses in accordance with the Milestones.

4.8 Project Evaluation

Table 38 concludes that the outcomes that need to be addressed for evaluation are:

- Engineering Codes and Standards
- Economic factors
- Sustainability
- Manufacturing
- Health and Safety
- Legal issues
- Analysis tools

- Alternative solutions
- Team Dynamics
- Communication
- Project Management

Assessment tools:

Table 40 Assessment Tools

Fundamentals	Performance by student
Design	Evaluation of final reports Responses of sponsor surveys
Teamwork	End of the quarter peer review and faculty evaluation
Problem solving	Evaluation of final reports
Communication	Evaluation of oral presentations, proposals, and reports

By evaluating every Milestone and enforcing specific timeframes in which Milestones are to be completed the maximum success rate for project completion will be achieved. Students must present progress within the Gantt chart that they have created to avoid procrastination. This also simulates actual engineering projects in the industry.

4.9 Project Management Framework

For the project management framework template for Project Initiation refer to Appendix D. This compels projects to be focused and that the ultimate objectives and outcomes of projects are known before projects are initiated. By enforcing this framework project completion will be assured.

Students must also be able to complete the project management framework template for project initiation. This ensures that student fully understand the main outcome and aim of the project.

Project Lifecycle indicates each component, sequence and individuals required for the completion of a successful project.

For Project Lifecycle refer to Appendix C.

4.10 Project Management Structure

This combination of the Programmatic based management structure and the Matrix based management structure allows each project to develop on its own, with contributions of other projects within the research field. By integrating Ph.D, Masters and Undergraduate projects less strain is imposed on faculty members. This line of dependants forces each qualification plane to take responsibility for projects and project members exchange information with each other and less strain is applied to faculty members.

Each project must however still have a faculty members present to ensure that projects remain focused.

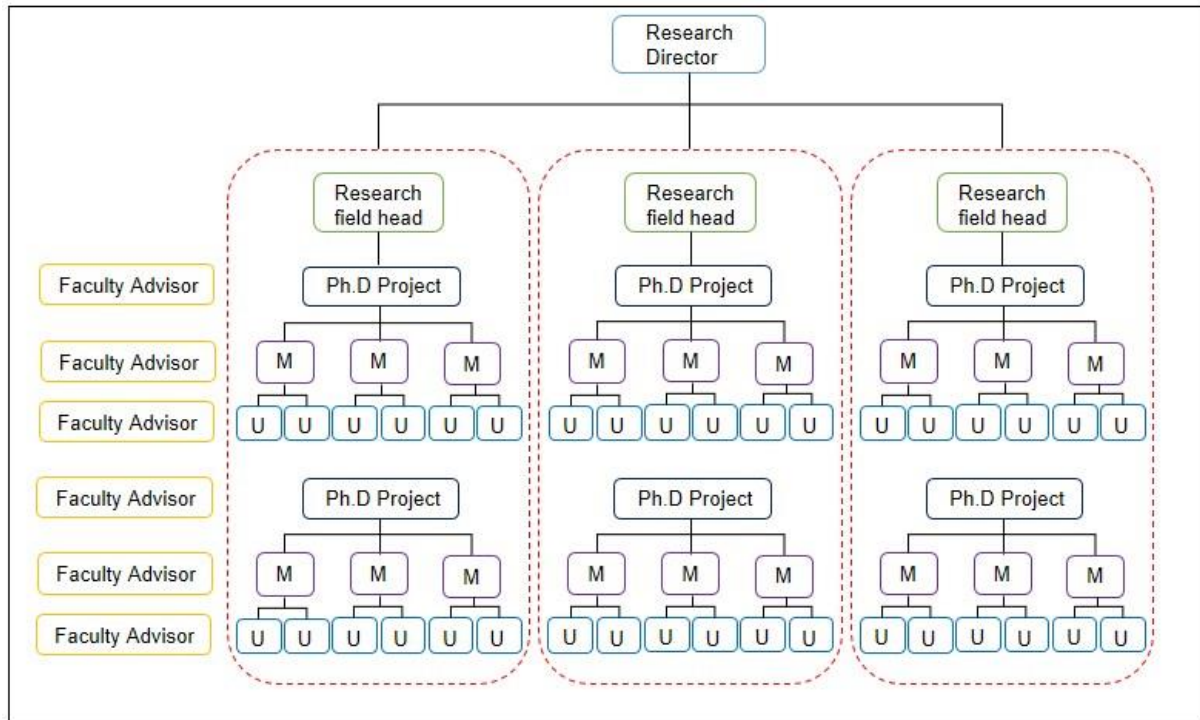


Figure 11 Combination Management Structure

5 Discussion

Currently student communication abilities are evaluated via a poster. The poster is only used for project day and requires money from the project budget. By implementing a project article instead of a poster student time is just diverted and this saves money. Project Articles are also more valuable for the Department and will contribute to the Department publications. Communication skills are still evaluated thus a project outcome is met.

Report Writing

Formal classes before Projects are initiated in Report writing must be applied.

6 Conclusion

According to Graph 3, there is an increase in student registrations at the School of Mechanical and Nuclear Engineering at the NWU, Potchefstroom campus. From the Survey the conclusion is drawn that the increase in registrations is proving to be problematic due to the inadequate project management structure for INGM 479.

The following aspects of the project management structure was addressed and concludes that:

6.1 Project Selection

- Projects must comply with the research groups of the faculty.
- Projects must comply with the number of credits devoted to the module in the curriculum

6.2 Faculty advisor

- A Faculty advisor is assigned to every project.
- The faculty advisor must have experience and practice in the particular field of the project.
- The outcome of each project must be known by the faculty advisor before project initiation.
- With the increase of registrations the time that project-leaders have available for project-leader related work is decreasing. This results in strain on students as well as project-advisors. Project leaders must spend approximately 2 workdays a week on project-leader related work with the increasing number of registrations. This limits the available time in a week to be able to focus on faculty member related work. If Project leaders spend less time than the minimum number of hours on each student and thus devote less than 2 days on project-leader related work students will then be negatively affected.

6.3 Project logistics

Group projects must be implemented to minimize the time spend on project by project-leaders. Group projects also resemble the actual working conditions for engineers in the industry.

6.4 Project Management Framework

The project management framework proves to be an aid to ensure the completion of a successful project. The project management framework template compels projects to be focused and that the ultimate objectives and outcomes of projects are known before projects are initiated.

Students must also be able to complete the project management framework template for project initiation. This ensures that student fully understand the main outcome and aim of the project. (Refer to Appendix D for Project Management Framework Template)

6.5 Project Management Structure

From the research it can be concluded that the combination of the Programmatic based management structure and the Matrix based management structure allows each project to develop on its own, with contributions of other projects within the research field. By integrating Ph.D level, Masters and Undergraduate projects less strain is imposed on faculty members. This line of dependants forces each qualification plane to take responsibility for projects and project members exchange information with each other and less strain is applied to faculty members

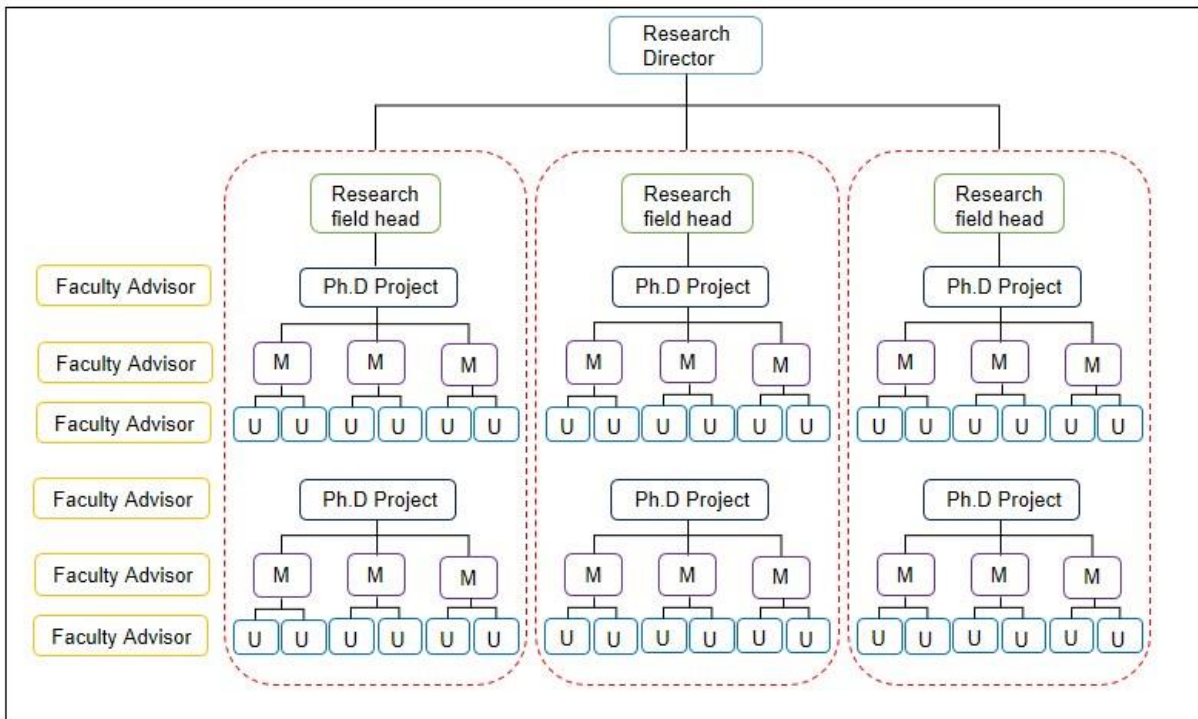


Figure 12 Combination Management Structure

6.6 Project Procedure

Project procedure indicates all the tasks, in sequence, with a description, persons responsible for the activity and the time frame which needs that needs to be conducted to ensure the completion of a successful project.

Task	Description	Person Responsible	Time
Project screening	<p>Project-advisors screen projects according to:</p> <ul style="list-style-type: none"> • Solvability within the prescribed credits for module in the curriculum. • Projects must require research and design. • Projects must require a team of 2-3 students. • Projects must not be with mainstream production. • Material and equipment for the projects must be easily available. • Projects must be in line with research groups of the Faculty. (Refer to 4.3 Project Selection for more information) 	Project-advisor	Five-week period in the semester preceding the final year Project
Project description	<ul style="list-style-type: none"> • Details of projects are carefully worked out. • Completion of Project Framework Template. (Refer to Appendix D) 	Project-advisors	One week.
Publication of Projects	Projects are submitted to students.	Project-advisors	One week after project description.

<p>Project selection by students</p>	<p>Project selection process by students:</p> <ul style="list-style-type: none"> • Listing all the projects. • Filter projects by considering long term goals. • Filter the new set of projects by considering short term goals. • Filter the new set of projects by considering the senior capstone course requirements. • Filter the last set of projects by considering available resources. Resources include: <ul style="list-style-type: none"> • time • money • technical knowledge • Select a project from the last filtered set of projects. 	<p>Students</p>	<p>One week after Publication of projects.</p>
<p>Project Allocation</p>	<ul style="list-style-type: none"> • Project-advisors are assigned to specific projects which are in accordance to their line of expertise. • Students are assigned to teams with regards to the projects that they selected. • Project allocations and teams are published. 	<p>Project-advisors</p>	<p>One week after Project selection.</p>
<p>Team meeting</p>	<ul style="list-style-type: none"> • Teams conduct their initial meeting and begin developing plans to learn more about their assigned project. 	<p>Students</p>	<p>Week prior of Project allocation.</p>

	<ul style="list-style-type: none"> • Completion of Project Management Framework Template. (Refer to Appendix) 		
Meeting with Project-advisor	<ul style="list-style-type: none"> • Students schedule meetings with the Project-advisor. • There is at least one scheduled, one-hour meeting with an instructor during this period. 	Students Project-advisor	Week prior of Project allocation.
Class	<ul style="list-style-type: none"> • Tutorials and lectures are conducted regarding: <ul style="list-style-type: none"> ○ teamwork ○ project management ○ time management ○ report writing • Students are made aware of facilities and administrative support that are at their disposal to conduct their projects. <p>These include:</p> <ul style="list-style-type: none"> ○ workshop facilities ○ computer laboratories and software project administrators. 	Students Project-advisor	Next two weeks.
Statement of Work	<p>Students must prepare a Statement of Work. This includes:</p> <ul style="list-style-type: none"> • Background. • Problem statement. • Objectives • Scope of Project • WBS • Overall planning. <ul style="list-style-type: none"> ○ main activities ○ responsibilities ○ overall time schedule 	Students	Week one.

Milestone 1 Submission	Milestone 1 is submitted to project-advisor. Project-advisor reviews SOW.	Students Project-advisor	Feedback within one week.
Milestone 1 Evaluation	SOW is evaluated	Project-advisor	One week from submission.
Meetings	<ul style="list-style-type: none"> • Students conduct team meetings. • Groups meet with project-advisor for feedback. 	Students Project-advisor	Every two weeks.
Milestone 2 Submission	Teams are required to submit a written Project Proposal that includes: <ul style="list-style-type: none"> • Front page. • Introduction • Literature survey. • WBS and Planning. • Source list. Project-advisor reviews Project Proposal.	Students Project-advisor	One week from submission of Milestone 1. Feedback within one week.
Milestone 2 Evaluation	Project Proposal is evaluated.	Project-advisor	One week from submission.
Text Editing	Milestone 3 report is send for text editing.	Students	One week before submission of Milestone 3
Milestone 3 Literature Review	Students must submit a literature review. Project-advisor reviews Milestone 3.	Students Project-advisor	Two weeks from submission of Milestone 2. Feedback within one week.
Milestone 3 Evaluations	Milestone 3 is evaluated. Milestone 3 is a Stop-Go evaluation. Projects are evaluated with regards to progress. If Milestone	Project-advisor	One week from submission.

	3 does not indicate sufficient progress and understanding of project, the project is stopped and students must enrol next year for project.		
Design Submission	Students complete and submit initial Methodology and designs. Project-advisor reviews methodology and designs.	Students Project-advisor	End of first quarter. Feedback within one week of submission.
Construction	IF design is approved construction initiation proceeds. Project-advisor reviews design.	Students Project-advisor	Final completion of construction at the beginning of term 2. Feedback within one week.
Milestone 4 Demonstration	Demonstration of project and testing of results. Milestone 4 is a Stop-Go evaluation. Projects are evaluated with regards to progress. If Milestone 4 does not indicate sufficient progress and understanding of project, the project is stopped and students must enrol next year for project.	Students Faculty-advisor	First week of term 2.
Methodology	Students collect results and data. Project-advisor reviews results and data.	Students Faculty-advisor	3 rd quarter. Feedback within one week.
Milestone 5 Written Report	Students submit a Written Report that consists out of: <ul style="list-style-type: none"> • Project Proposal. • Literature Review. • Methodology. • Findings. • Results. • Conclusion. 	Students Faculty-advisor	End of 3 rd quarter.

	Project-advisor reviews written report.		Feedback within one week of submission.
Milestone 6	Project-advisor select external examiner for project evaluation. Student reports are presented to external examiner one week prior to Milestone 6.	Project-advisor	
Article	Students submit an article of the project for publication. Faculty-advisor reviews article.	Students Faculty-advisor	First week of quarter 4. Feedback within one week of submission.
Milestone 6 Project Day	Students present projects to student peers and evaluation panel that consists out of external examiners and other faculty advisors.	Students Faculty-advisor Evaluation panel	First week of quarter 4.
Milestone 6 Evaluation	Presentation, report and article are evaluated by the faculty-advisor. Evaluation panel evaluates presentation. External examiner evaluates report.	Faculty-advisor External examiner Evaluation panel	Grading one week after Milestone 6

6.7 Tools

From the research, Table 41, provides tools that prove to be of aid, for final year project management structure to students and project advisors.

Table 41: Tools that prove to be an aid for final year project management structures.

Tool	Description
Text Editing Services	The implementation of text editing services will decrease the number of hours that each project-leader must spend on rectifying student reports and thus on the average number of time spend on project-leader related work.
Statement of Work	Projects must comply with the Statement of Work as indicated in Appendix D. This assures that the project is constructed within the limits of the faculty and student ability.
Project Gantt-Chart	This ensures that the project will be completed successfully with in the timeframe provided.
Project Milestones	Milestones require students to complete certain aspects of the project within a specific timeframe. This helps students by breaking up the project in specific divisions thus allowing students to focus on a small part of the project at a time. The progress of the project can then be asses in accordance with the Milestones.
Project Management Framework	<p>For the Project Management Framework Template for Project Initiation refer to Appendix D. This compels projects to be focused and that the ultimate objectives and outcomes of projects are known before projects are initiated. By enforcing this framework project completion will be assured.</p> <p>Students must also be able to compile the project management framework template for project initiation. This ensures that student fully understand the main outcome and aim of the project.</p>
Project Lifecycle Schematic	The Project Lifecycle schematic indicates each component, sequence and individuals required for the completion of a successful project. (Refer to Appendix C)
Project Management Structure	This combination of the Programmatic based management structure and the Matrix based management structure allows each project to develop on its own, with contributions of other projects within the research field. By integrating Ph.D level, Masters and Undergraduate projects less strain is imposed on faculty members. This line of dependants forces each qualification plane to take responsibility for projects and project members exchange information with each other and less strain is applied to faculty members.

7 Recommendations

Recommendations include:

- Projects must comply with the number of credits devoted to the module in the curriculum.
- Projects must be integrated so to comply within the research fields in each faculty. (refer to Figure 3)
- Implementation of group projects. With group size between 3 and 4 students per project.
- Strict completion of the Project Management Framework Template for faculty-advisors, before project initiation, as well as students. (refer to appendix D)
- Compulsory classes, integrated within the project lifecycle, covering the following topics:
 - Writing Abilities
 - Teambuilding
 - Team Dynamics
 - Leadership
 - Drawing, Creativity or Concept or Generation
- Implementation of text editing services for report corrections.
- Designing projects within the Project Management Structure.
- Completion of a Gantt-Chart by the faculty-advisor, before project initiation, and students.

8 Recommendations for further study

The recommendations for further study include:

- Impact of projects on faculty workshops.
- Aids for faculty workshops.
- Industry sponsored projects

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Appendix A

Survey

Please complete the following survey, with a cross where applicable, in regards to INGM 479. In accordance to the NWU ethical code all respondents will be kept anonymous.

1. Gender

a) Male	b) Female
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2. Year of birth

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3. Are you currently a Final-year Project leader?

a) Yes	b) No
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4. If not, please indicate the reason.

a) Too time consuming
b) Insufficient time
c) Money
d) Experience
e) Please specify other

5. How many years have you had experience being a Project leader?

--

6. How many project students do you currently have?

--

7. Please indicate which method of communication you use with your students in regards to the time periods as indicated.

	On a weekly base	On a monthly base	On a termly base	In a semester
a) e-mail				
b) efundi				
c) Individual meetings				
d) Group meetings				
e) Other				

8. Please indicate the average number of hours per student you spend each week on Project leader related work, in regards to the Milestones as indicated.

	0h-1h	1h-2h	2h-3h	3h-4h
a) Planning project				
b) Milestone 1				
c) Milestone 2				
d) Milestone 3				
e) Milestone 4				
f) Milestone 5				

9. Would you consider group projects?

a) Yes	b) No
--------	-------

10. Please indicate how you feel, in general, towards the Final-years Project (INGM 479) in regards to the Milestones as indicated.

	Extremely negative	Negative	Neutral	Positive	Extremely Positive
a) Planning project					
b) Milestone 1					
c) Milestone 2					
d) Milestone 3					
e) Milestone 4					
f) Milestone 5					

11. Do you experience the following grievances in regards to the Final-years Project (INGM 479)?

a) Incompetence of students report writing abilities.	Yes	No
b) Marking problems from Milestone 3 (Detail Design) and onwards.	Yes	No
c) Please specify any other grievances		

12. Please indicate if the following will assist you as project leader.

a) Text editing services for students reports	Yes	No
b) Templates for students reports	Yes	No
c) Fixed Milestones	Yes	No
d) Fixed marking sheet	Yes	No
e) Final-years Project leader assistant	Yes	No
f) Please specify any other suggestions		

Appendix B

Survey 2.0

Please complete the following survey, with a cross where applicable, in regards to INGM 479. In accordance to the NWU ethical code all respondents will be kept anonymous.

1. Please indicate the average number of hours per student you spend text editing their reports? This includes grammar and spelling corrections on reports for Milestone 1, Milestone 2 and Milestone 5.

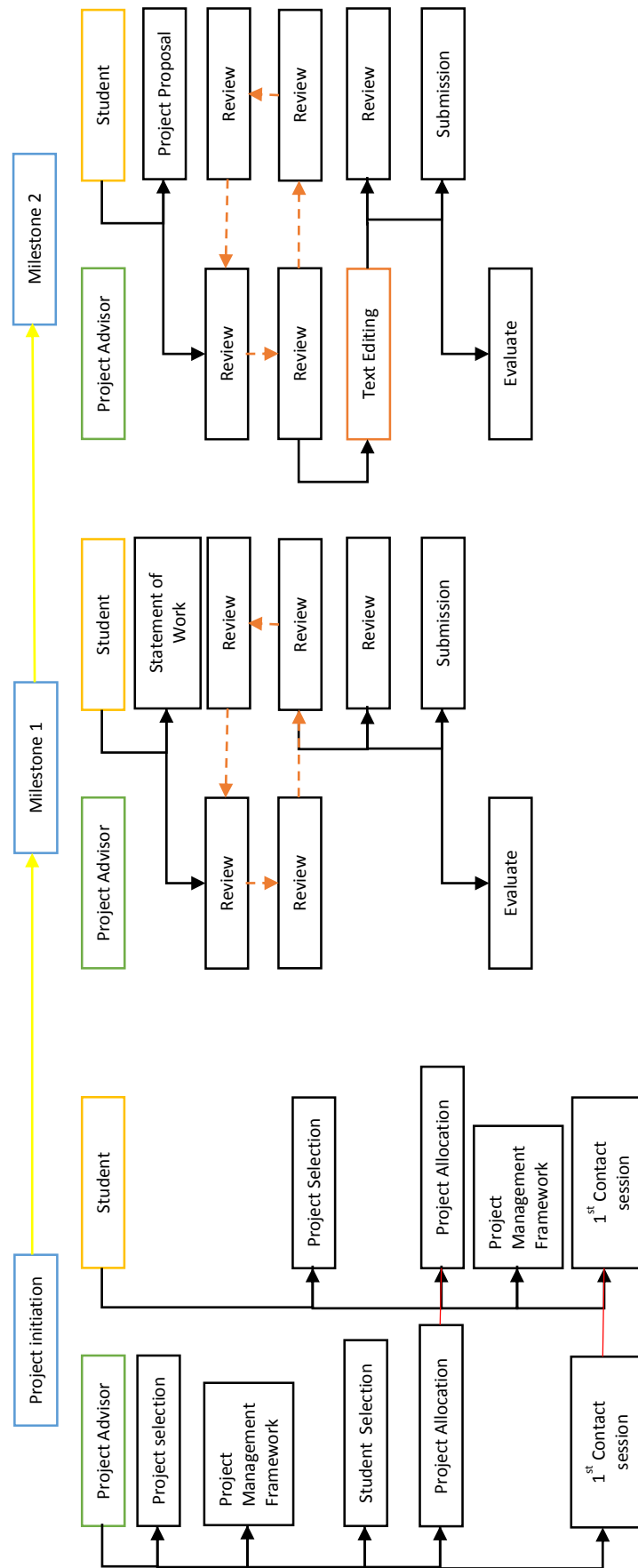
	0h-0.5 h	0.5h-1h	1h-1.5h	1.5h-2h
Milestone 1				
Milestone 2				
Milestone 5				

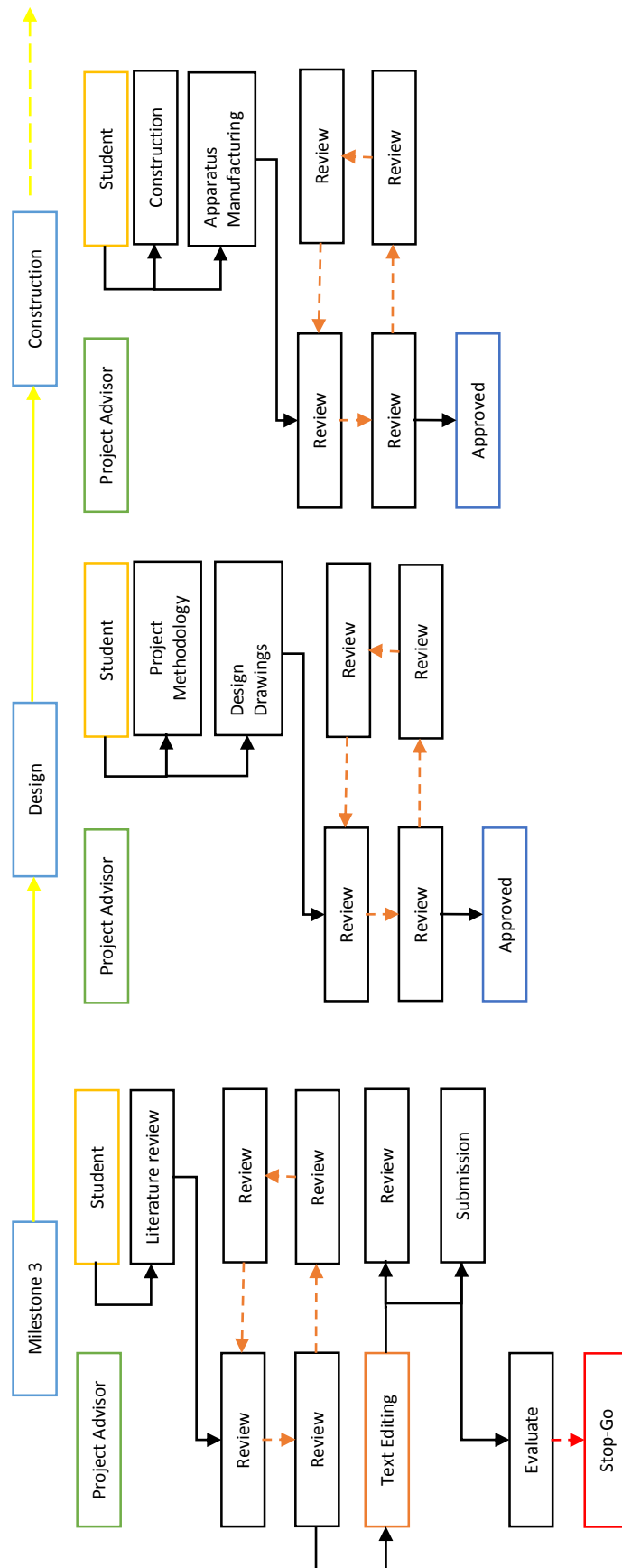
2. Please indicate the average number of pages per student for each report.

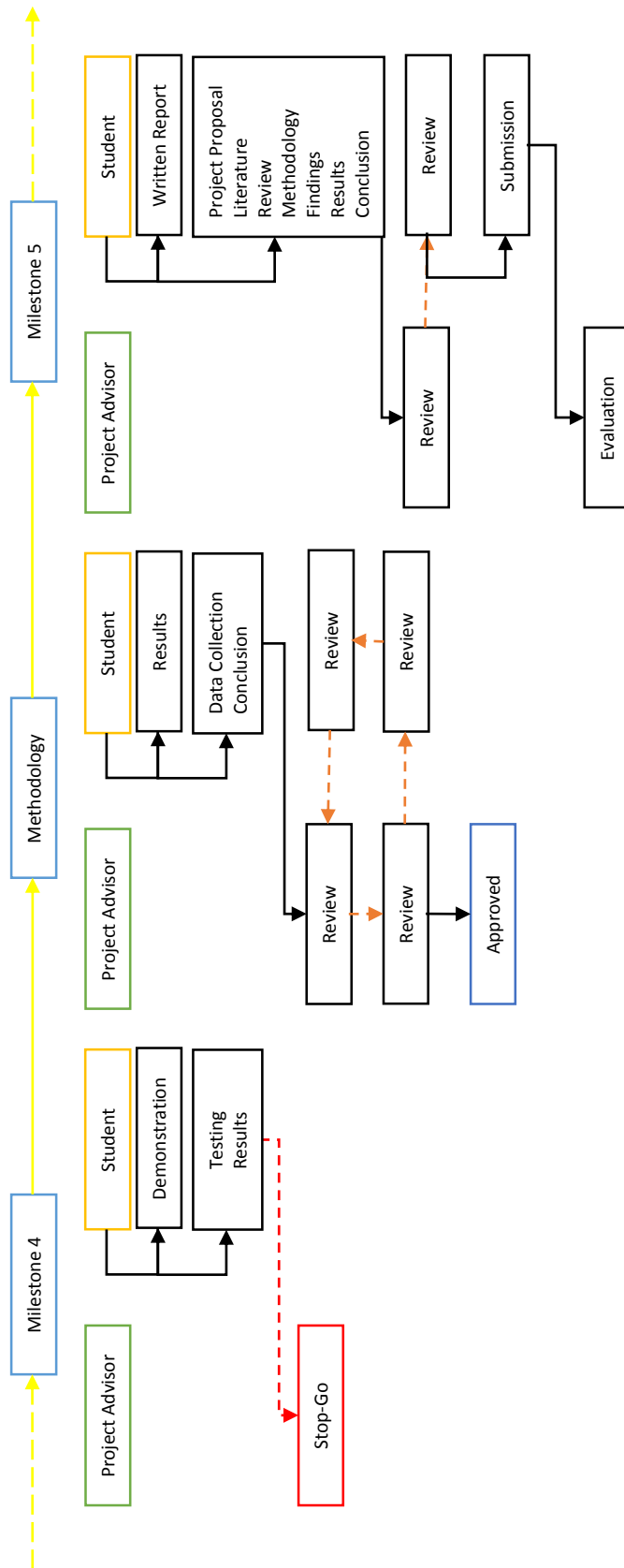
Milestone 1	
Milestone 2	
Milestone 5	

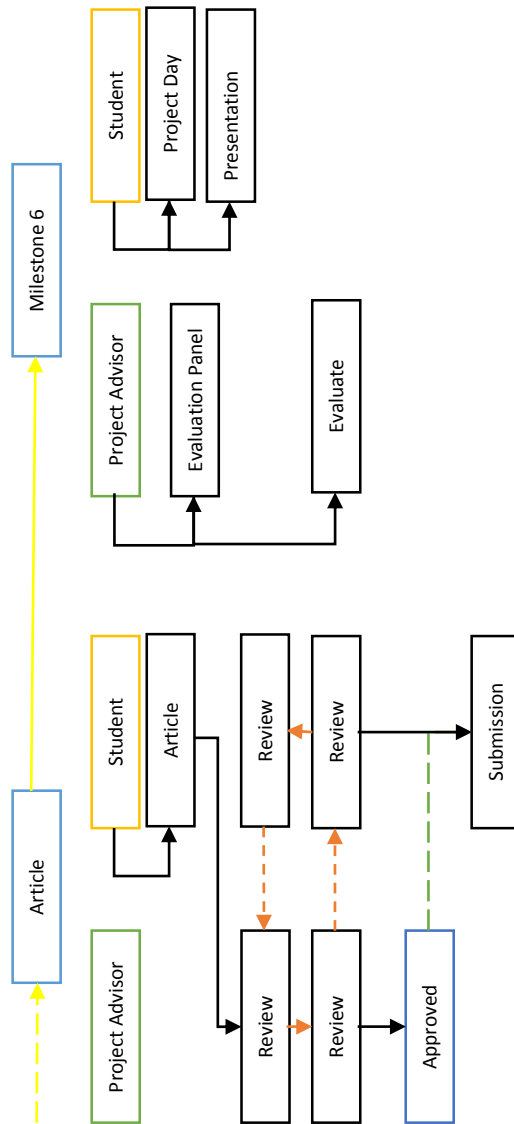
Appendix C

Project Life Cycle









Appendix D

Project Frame Work

Project Management Framework Template

Scope

(Overview of Project 15-20 words)

Background

(Reasons for recommending the project. Include background information, business problem, etc.)

Vision

(Idealistic outcome of the project.)

Goal Statement

(Provide the overall context for what the project is trying to accomplish.)

Objectives

(Include specific, measurable, attainable, realistic, time-bounded, concrete objectives for achieving the goal.)

Deliverables

(Include deliverables that will be part of the project.)

Assumptions

(The events that need to occur for the project to be successful but are outside the total control of the team.)

Constraints

(Limitations generally outside the control of the project which may negatively impact the project scope.)