



Module 1.4 Project Management

Introduction - The successful management of a research project depends upon the research team's ability to plan, coordinate, and perform the research. Although some research teams who do not formally manage their research are successful, using this approach can have a stressful impact on team members and others who are involved in the project. Usually when a team neglects formal project management techniques deadlines are not met, the project's scope is poorly managed, and poor time management leads to poor outcomes. This document outlines some of the key tools you can utilize in 10.26/27/29 that lead to more successful outcomes.

First and foremost, clearly understand what success means for your project and what your objectives are and how you will achieve them. A simple model for exploring your objectives is to use a tool called the Logical Framework that distinguishes between outputs and outcomes. Outputs are the goals of the project. Outcomes happen as a result of the outputs. For example, in your research project the outputs are the written papers, oral presentations and analyzation of the data with the related outcome being the experimental results that proves or disproves your hypothesis. The project starting point is to define the desired outcomes leading to the outputs being defined. In effect you are "starting with the end in mind" enabling you to focus the research effort. You have a relatively short period of time to develop your research skills and produce a significant piece of work – being clear about what your team is trying to achieve will allow the team to focus their efforts.⁽¹⁾

Definition - Project management is the discipline of carefully planning, organizing, motivating, controlling resources and people to achieve definite goals and meet specific success criteria.⁽²⁾ Additionally, project management is the application of knowledge, structures, skills, tools, and techniques to project activities to meet the project requirements. Historically, managing projects was practiced informally, but currently formally implementing a project is considered as integral a skill as technical knowledge. Projects are temporary endeavors undertaken to create a unique product, service, or result, having a defined beginning and specific end with a defined scope and resources. A project is unique in that it has a specific set of operations designed to accomplish a singular objective. A project team often includes people who don't usually work together. Examples of projects are the development of software for an improved business process, the construction of a building or bridge, the relief effort after a natural disaster, and as in this course initial research into a problem that industry wishes to solve. Projects need to be expertly managed to deliver results in a reasonable amount of time to promote the needed innovation.

Project Management Skills – Researchers⁽³⁾ found working on a team increased productivity and collaborating on a project helping to create a sense of group identity by developing feelings of support and unity, beginning with the leader being allowed to show more interest in team members as individuals and the project's processes and changes. Today individuals making decision on their own is rare. Successful companies operate with teams of people who combine their ideas, judgments, and strategies. Teams share information, implement and maintain projects, conduct meetings, and complete tasks. An effective team can improve efficiency, obtain research results, and boost morale. However, working on a team does take more effort than working independently because each person must devote time to building and maintaining relationships with the other team members.

Types of Teams -*You will be on what is called a Limited-life team. These teams are created for specific purposes and once fulfilled, the teams are disbanded. Examples of limited life teams include a development team designing a new product, doing research on a specific problem, or a task force created to resolve a specific problem. Ongoing teams have no identified ending point. An example of an ongoing team would be a department team that meets regularly to plan, review goals, and assess performance. There are three basic team types:*

Working groups also called natural teams because they are formed naturally from the work that needs to be completed. Work groups have responsibility for a specific process such as a department or product. In this type of team, members are more productive as they have responsibility or they work under direction from a leader.

Process teams are usually limited life teams that are created for a specific purpose. That purpose may be to achieve a goal or solve a problem.

Self-managed teams manage the daily operations of their section, department, or product. Their levels of responsibility and authority may vary depending on the company.

Working in teams allows people to be more creative by bringing in different views, fresh ideas, and new perspectives, allowing for diversity, and resulting in finding the best way to achieve goals. Research⁽⁴⁾ has shown that effective teams can increase motivation when all members share responsibility and celebrate their successes. Advantages to working on a team are distributing the work, reinforcing individual skills, and strengthening connections.

Distributing the Work - *Independent tasks* are tasks that do not need to be completed in a specific order, can be finished at any time, and use different resources.

Interdependent tasks rely on the completion of other tasks or shared resources. Sometimes the task to be completed is so large that the work must be divided (or shared) in order for the task to be accomplished efficiently. In this course, project leaders divide these tasks into parts and assign them to individual members. Then each member works independently, and the parts are combined to accomplish the end

results. A good example of this would be the research project you are about to embark upon. Some tasks will be divided and done individually while other tasks cannot be divided, such as writing your final report collaboratively. While there will be tasks of drafting, proofreading, and distributing. One team member can also accomplish the actual final editing, although some teams accomplish the final edit together.

Reinforcing Individual Skills - "The team is more than the sum of its parts." By combining people with different skills, not only are different views and perspectives given, but also skills are combined and reinforced. For example, choosing one member as a technical advisor for the collaborative writing assignments, to make sure the technical aspects are included accurately could be combined by choosing the team member with the best editing skills and technical expertise or if only one member is a good editor and another is the technical expert on the team, the task can be divided. Developing skills can be time consuming. Teams may want to allow a team member with the weakest editing skills to develop their skills but this can cause the final report to be less comprehensible and inaccurately state what the other team members want to communicate or the team member with the least amount of technical knowledge editing the final paper can create a paper that does not communicate enough technical information. The team leader must make difficult decisions in regard to time management, how to develop team members' skills without effecting the quality of the team's products. Working as a team can allow people to gain new skills or expand their skills by working closely with others who are very competent. For example, if a project requires a database to be developed, a team member with no database skills could learn the basics of how to design a database, and a person with minimal database skills could learn more skills from the expert.

Project Management Twelve Knowledge Areas:

Team Formation	Time Management	Resource Procurement
Synthesis	Scope	Cost
Communication	Risk Management	Resource Management
Team Maintenance	Conflict Management	Leadership Skills

Project Management *Processes* in 10.26/27/29

Conceiving: Your faculty advisor has conceived your project for your team. You have a project description with the initial conception of the project. Your team's objective is to formulate a plan for initiating, planning, and executing the project.

Initiating: In 10.26, initiating begins with forming and structuring your team. In most organizations, people are assigned to a project because of their technical not their interpersonal skills. The need to structure communication processes is essential therefore team formation must happen before the team members begin to work together. Our initiating process is unique in that it begins with discussions about time limitations, expectations, and members' strengths and weaknesses in specific areas that are integral to the project's success. Other initial discussions are about your team's vision and ground rules that are systems your team will use to execute tasks. Lectures are given on creating Ground Rules, Mission Statements, and Situational Leadership.

Poor team formation can lead to communication issues and conflict between team members, especially when individual member's objectives are focused on competition for their ideas or limitation on time spent on creating a plan. Also poor management of other people involved in the project can also be detrimental therefore analyzing the power of the other people involved is essential. How will team members influence the outcomes of the project? For example, the people working on the project can have a large impact on the outcome of the project because if they disagree on how the project will be implemented they are unlikely to support implementing the experiments. Motivation will be low and attention not focused.

How will others influence how the outcomes will be met? For example the technical and administration staff on a project can have an impact on the outcomes of the project therefore establishing good communication systems with others is beneficial. In 1026 your team will deal with safety issues, ordering, library searches and how expertly you learn to manage your laboratory equipment and seek out other resources with the help of others will affect your project's outcome. For example, operational staff, who often include technical and administration staff, such as your safety advisor, teaching assistant, and project management coordinator will have the overview of the project explained to them by the team, while the faculty advisor and the industrial consultant may need the details explained.

What are others' expectations and how does the team integrate these expectations into the goals of the project? The key outcomes of this part of the project management analysis process are an understanding of how the people involved in the project especially the project team will initiate and implement the project and an understanding of the dynamics of the industrial consultant in relationship to the faculty advisor and others working on the project will impact the time constraints of the project.

Executing: A successful Project Leader must simultaneously manage the four basic elements of a project: resources, time, money, and most importantly, scope. All these elements are interrelated. Each must be managed effectively. All must be managed together if the project and the team are to be a success.

1. **Resources** - People, equipment, material
2. **Time** - Task durations, dependencies, critical path
3. **Money** - Costs, contingencies, profit (this item is minimized in this course)
4. **Scope** - Project size, goals, requirements

The need to balance the fourth element is the most important task for a successful project leader. The project scope is the definition of what the project is supposed to accomplish and the budget (of time and money) that has been created to achieve these objectives. It is absolutely imperative that any change to the scope of the project has a matching change in either time or resources. A project can increase in scope because of unforeseen circumstances. An idea for a project change will be carefully examined to determine whether or not it benefits the team as well as the project's outcome. During this phase, the team will make decisions to identify if the project can realistically be completed in a timely manner or if the scope needs to be changed. For example, the initial project scope is to research how to reduce the amount of water needed to operate and maintain a US Army toilet. Then the team is asked to include a reduction in waste and water used in the base camps in other areas. The project leader must obtain an appropriate change in budgeted resources such as time, resources and technical skill level of team members. If the resources cannot be adjusted, the smart project leader will avoid the change in scope.

Usually, scope changes occur in the form of "scope creep". Scope creep is the piling up of small changes that alone are manageable, but in aggregate are significant. For example, the project calls for toilet efficiency to be increased but the client decides that efficiency of the entire waste removal system should be included in the project. The client wants to add the objective of making sure that the plumbing system works efficiently from the toilet to the sewer. Looking at the flush system in relation to the sewer could be a minor change. Later the client wants a separate report on your observations of the sewer system. This could be considered another minor change. But taken together the two minor changes has become a major impact upon the team's resources of time and planning for the project. As a project leader you cannot effectively manage the resources, time and money in a project unless you actively manage the project scope. When you have the project scope clearly identified and linked to the timeline and milestones, you can begin to manage the project resources. These include the people, equipment, and material needed to complete the project. Then if there is time you can add in the changes asked for by others.

Monitoring and Controlling: Project leaders will compare project status and progress to the actual plan, as the scheduled work is performed. During this phase, project leaders may need to adjust schedules or do what is necessary to keep the project on track. Oral presentations, written reports, and meetings will help to keep the project on track. Regular communication is an important aspect of successful planning. You need to discuss on a regular basis with your team members, faculty advisor, industrial

consultant, and project management coordinator how the team and project are progressing and meeting milestones. Teams are informed of responsibilities while resources and tasks are distributed. This is a good time for the team to discuss important project related information. In 10.26 procedures that will help you successfully monitor and control your project:

1. Meetings with your team, faculty advisors, project management coordinator, and writing instructors
2. Oral Presentations
3. Periodic Written Reports
4. Weekly Progress Reports
5. Agendas
6. Activity Lists with team deadlines for tasks
7. Meeting Minutes
8. Team Calendar

Project Scheduling: In 10.26 the project schedule is created using the Logical Framework and Proposal as guides. These documents should communicate what work needs to be performed. The Activity Lists in “Work to Be Done” in the Weekly Progress Reports is where the Project Leader records who will perform the work and the time frames. The project schedule should reflect all of the work associated with delivering the project on time. Without a full and complete schedule, the project leader will be unable to communicate the complete effort, in terms of cost and resources necessary to deliver the project. Weekly Progress Reports with activity lists allows project leaders, faculty advisors, the project management coordinator and the team to track resources and milestones in real time. The Activity Lists and Logical Framework should be reviewed and updated by team members in order to keep everyone well informed on the overall project status.

The building blocks of a schedule starts with the Logical Framework. The Logical Framework is a hierarchical reflection of all the work in the project in terms of deliverables. In order to produce these deliverables, work must be performed. A typical approach in developing the Logical Framework is to start at the highest level, with the reason of the project. For example, the research project’s objective is to fabricate, characterize, and assess the performance of super hydrophobic PVDF fiber membranes for the desalination of water during membrane distillation. Several deliverables for this project is to assess the performance of 15 wt%, 18 wt% and 20 wt% PVDF membranes by Air Gap Membrane Distillation or DMF solution to find the critical concentration needed for electrospinning. The objective for the team and the milestones for the project need to be decomposed so that the team can initiate the tasks. The objective is the first level of decomposition and the aforementioned deliverables are second level outputs.

Decomposition is the process of breaking down the work into smaller, more manageable components. The elements at the highest level are decomposed on the Logical Framework while the elements at the lowest level are tasks and are summarized and delineated on a weekly basis on Activity Lists that are communicated under “Work to be Done” in the Weekly Progress Reports. The decomposition of a schedule will continue at varying rates. Initiating an experiment is a task identified at the third level of decomposition, while the steps and who will do the steps in the experiment are also a task, but defined at the fourth level of decomposition and created on a weekly Activity List.

As a project leader, the level of decomposition will be dependent on how much communication amongst others is needed. The expectation is that each task will be assigned to a single team member and the member is expected to manage and report on the work necessary to deliver the task. If you cannot assign a single team member, or you need to have additional visibility into the progress of that task, additional decomposition is recommended. This information is recorded on the Activity Lists.

Duration is the expected time frame needed to complete the task while taking into consideration the skill level and general availability of the team member and/or equipment. Duration estimation should be realistic. If the activity is expected to take two weeks, but historically, team members are only available 70% of the time due to other classes, meetings, holidays, vacations, sports, etc., then planning a duration of three weeks may be more reasonable.

Assigning work is as much about team members’ attitudes as it is about executing the project. Most individuals prefer to have a clear understanding of the work that needs to be performed. Team members require focused attention to the task in order to deliver the highest quality work. Studies have shown that if an individual is juggling more than three tasks simultaneously, the efficiency of his/her work is compromised. In addition, without clear prioritization of tasks, it is human nature for people to work on tasks that they feel most comfortable with and not necessarily the ones that are most important to complete. Once the project’s goals are identified, tasks are performed to reach the goal outcomes. In some cases, these activities are the physical results, but in other cases they are activities that need to be performed. A physical result, for example, photos or graphs used for a report or oral presentation. Listing out each of the tasks to be performed will result in an activity list addition. In this course we teach Situational Leadership that allows you to acknowledge personal expectations and strengths and weakness analysis as a method for considering who should be assigned what task and what instructions the Project Leader will give in order for the team member to accomplish the task. As the project leader, understanding basic human tendencies is critical in effective execution of a plan.

A good Activity List is a schedule that is as detailed as possible for the information known, and the types of resources needed for each task. A good activity list will have a single team member on each task with duration times. The Project Leader’s

task is to decide what skill set is required to accomplish the task, which your team will discuss in regard to your individual strengths and weaknesses as well as your expectations. In order to assign tasks to individuals, it is necessary to know the expected duration of a task as well as the individual resource availability, skill level, and knowledge. Before assigning individuals to tasks, it is recommended to associate a task with knowledge, motivation, and skill level. Then enter the expected duration of that task based on the team member chosen and what resources are needed. The objective is to associate a responsible team member with the appropriate skill set to each of the tasks. Remember that teaching assistants also have task assignments within your plan. Remember when a team member volunteers for a task this does not mean that they have committed the time and have the knowledge to do the task in a reasonable amount of time. It is the project leader's responsibility to analyze if the team member can accomplish what the team member says they can do in the time allotted with the proper skill level.

As you are aware, projects are unique events, it is inevitable that schedules will change and work assignments will be modified. Therefore, creating Activity Lists on a weekly basis and making smaller, more regular assignments to individuals, keeping in mind their expectations, skill level, and motivation will minimize confusion and produce better results. Some of the benefits of using the Logical Framework, Activity List and the Weekly Progress Report include:

1. Understanding fundamental elements of the project
2. Identifying key tasks
3. Provides a framework for delegation and resource identification
4. Provides a method to manage and measure progress
5. Provides a basis for developing time estimates
6. Creates deadlines for project's milestones
7. Increases flexibility for arranging activities in the project.

One approach to developing the Logical Framework and the Weekly Progress Reports with Activity Lists is to view them as a collective mind-map of the tasks involved in the project. In the planning process the details will be expanded as the project progresses and a more detailed understanding of what is required will be explicated. For example in the literature review, once you have a high level system for implementing the activity in your ground rules the team might choose to assign the papers to read and summarize into a couple of key topic areas once it is clear what these topics are. Then the project leader can start to estimate the duration of the tasks on the team's activity lists. When implementing the activity lists the Project Leader needs to consider:

1. If you have done research in the past, a task that takes you little time may take a new researcher a significantly longer period of time.
2. If there are repetitive tasks in the research (e.g. Writing up an experiment protocol/ performing a specific experiment) you may want to do some timing of a typical

protocol in order to develop a realistic time scale for the whole task.

3. You often get better results when you are working with people if you get them to indicate how long the task may take to complete.
4. You should however do a reality check when asking someone – the biggest problem is people underestimating how long something will take to complete.
5. Once you have the Activity List started and durations of the tasks you can then start to develop the proposal for the project.

In developing the Proposal, your team will want to:

1. Think about how you can design your project so that activities can run concurrently. This has the benefit of allowing the team members to work on more than one task at a time, which can help with your motivation especially when the work contains repetitive experimental work.
2. Put in place the constraints between tasks that describe the logical order in which you should do the activities. At times these may be upon you (for example researching what materials you need before starting the work) but at other times it is likely that you will have to use your own judgment to decide upon the logic.
3. Make sure the Proposal reflects a plan for the project that the entire team has agreed upon and can be changed and adapted as the project progresses.
4. When you have developed your Proposal Outline the final stage in the process of developing the timeline for the project is to check that it makes sense and that the resources are in place to complete the work. One common mistake is to assume that many tasks can be overlapped and the plan does then not reflect the constraint on the resources.
5. Once you have the Outline you can then identify the critical path activities. These are the activities which if they do not start and finish on time will have an adverse effect on the duration of the project. Often in research projects these activities seem less immediately important than others but if they are not managed properly can have a negative impact on both the project and individual team member's ability to perform.

Project Resource Allocation and Resource Management: The resources of an organization consist of people, materials, equipment, knowledge and time. Organizations typically have limited resources; therefore, tradeoffs on what project resources are expended and when are made every day within organizations. A resource allocation plan is an important tool in effective management of scarce resources. In 10.26 sometimes 2 or 3 teams may need to use the same equipment at different times. When each team can use the resource will need to be allocated and planned. The timing of the need of those resources can be and should be determined within the Activity Lists or as a separate Resource Plan included in the Weekly Progress Report. A resource plan, which describes the type of resource needed and the timing of that need, is critical to effective resource management. As the Activity Lists change, the resources needed must be considered and adjusted.

Most likely, when starting a project, the Project Leader won't have all of the necessary resources assigned to the project because some of the details are typically unknown. Therefore, knowing the types and duration of resources necessary is not always possible. Known goals are events that can be planned. In structuring the Logical Framework, some goals can be decomposed in sufficient detail creating tasks, while other goals will only be known without a procedure to follow to the agreed upon outcome. When details of a goal are not sufficiently known, a plan stating the unknowns should be submitted in your proposal. The details of the goals defined within the unknown outcome can be considered unknown outcomes, or risks. In these instances, the work has not been fully decomposed. Known goals and outcomes, as well as unknown plans, can be assigned individual resources and time allocations that have been established by the team. The only difference is with unknowns the duration and resource estimates are typically less accurate. In order to make your proposal more definitive your use of historical information (papers written by last year's team) or industry standards can provide a higher degree of confidence in estimates, when available.

It is not necessary to have all goals decomposed and assigned to individuals prior to beginning work on a project. In fact, it is very common to set a baseline schedule and resource plan based on estimates. As the project progresses, these unknown goal outcomes become clearer to the project team warranting changes within the Logical Framework and Proposal.

Managing Risk within the Project: Within every project there are risks that if they occur would impact on the success of the project. For example in the research environment some of the risks that your team might face include:

1. One of the research team members being sick or leaving for interviews
2. Poor quality data is obtained
3. Key pieces of equipment breakdown
4. Materials needed to test are not readily available

The secret to managing risk well is to have thought through what might go wrong and to develop strategies to manage the key risks. To identify the key risks have a brainstorming session and identify risks as a team. Decide upon how much impact these risks might have on your project. In order to assess the impact you will want to think about expectations, individual skill development and schedule impacts. Give each risk a score for impact between 1-low and 5-very high. Decide how likely the risks are to occur. If something is certain to happen then it should not be treated as a risk but placed in the main plan. Give each risk a score for likelihood between 1 and 5.

Risk Mitigation Approach

1. Team member absent:
 - a. Training of other project members in techniques
2. Poor quality data:
 - a. Pilot experiments
 - b. Review data frequently
 - c. Build in redundancy to the data collection process
3. Equipment Breakdown
 - a. Maintenance and Spares
 - b. Identify alternative locations (Can you borrow the equipment?)
 - c. Develop more than one workflow.

Managing the Project: Once you have gone through the planning process you need to think about how you are going to actively manage the project. There are two key elements; (1) understanding how the project is progressing and (2) decision making to get the project back on track. Use the tools you have been given in 1026 to gain information about how the project is progressing. Use the combination of reports and meetings to achieve a method for progress measurement. For example the Weekly Progress Reports are good at focusing the team on working on the project while meetings give a space for discussing the progress of the project and for the leader to assess the mood within the team and to gain more knowledge from the faculty advisor. If you identify through the progress reporting that the project is not progressing as planned then you will need to take action. The first thing to do is to avoid blaming individuals for the problems that are being experienced in the project. If you do blame individuals they are less likely to report problems in future. The second thing to do is to make a decision about the course of action. If the problem sits without some sort of action the problem is likely to escalate (problems rarely disappear). In order to take the correct action it is imperative that action be taken at the cause level and not the symptom level (the classic example of this is working harder to solve a problem and discovering that no matter how hard the team works the problem does not go away). In order to take corrective action ask the question “Why?” several times till you get to the root cause of the problem and then take action at this level.

Managing Project Changes: Change requests are inevitable in any project. Successful project managers effectively manage changes and they are recorded in the Weekly Progress Reports. In 1026 the team meets on a regular basis with your faculty advisor to review and prioritize changes presented during the course of the project. The team will also meet on a regular basis with the writing instructors and the project management coordinator to increase knowledge in writing and project maintenance tasks associated with maintaining team performance. There are three categories of changes that can occur:

1. Necessary changes in order to meet the objectives of the project.
2. Changes that were not part of the original scope but are mutually approved by your faculty advisor and the team along with the associated approved change in the schedule. Typically, these changes are in response to:
 - a. A change because of the results from an initial experiment
 - b. Additional knowledge forcing a modification in scope
 - c. A new technology or product that may not have been available earlier in the project life cycle, but would significantly improve the probability of project success
3. Changes that were part of the original scope. The assessment of the faculty advisor and team that certain tasks are not required in achieving the project objectives.
4. Changes due to equipment repair or modifications.

Changes should be quantified, analyzed and prioritized using some form of a ranking system. Having a pre-defined ranking system will facilitate decision-making by making the decision an objective choice, eliminating emotional reactions. Keeping decisions as objective as possible will minimize unnecessary work affecting the overall success of the project. Team members are empowered to add issues and to escalate problems or changes to other members of the team or to the faculty advisor, teaching assistant and project management coordinator. Agendas, Activity Lists and Weekly Progress Reports are designed to track problems and changes that come up on the project or task level.

Time Tracking: Your role as project leader is to ensure that the project you manage is in line with expectations. This includes re-evaluating a project that cannot produce the intended outcome. Successful leaders have incorporated various incentive programs in order to modify the culture and behavior of teams. In 1026 time is a scarce resource and needs to be tracked so that the project scope is in line with the amount of time available.

Closing: After project tasks are completed and the advisor has approved the outcome, an evaluation is necessary to highlight project success, which we call the Final Report for the research and the Completion Report for the team performance. Your team will schedule an Exit Conference to discuss the details of your team's performance.

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