

Board 428: Utilization of Social Management Theoretical Framework and Program Management Tool to Successfully Manage Large Multi-Department STEM Projects

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Pursuing continuous financial support is an integral part of Dr. Rahman's research agenda Over the years, Dr. Rahman –received (as both PI and Co-PI) several competitive grants for both Imaging Informatics and

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Utilization of Social Management Theoretical Framework and Program Management Tool to Successfully Manage Large Multi-Department STEM Projects

Abstract

The Adapting an Experiment-Centric Teaching Approach to Increase Student Achievement in Multiple STEM Disciplines is a sponsored experiment-focused hands-on teaching pedagogy developed to promote motivation and academic achievement across seven STEM disciplines. The program is a large educational program with multi-Department STEM projects comprising approximately 200 tasks and 40 personnel. To facilitate the successful implementation of this STEM program, an efficient project management tool called Smartsheet was adopted to manage all the tasks to be carried out and the activities involved. Smartsheet software has helped facilitate efficient project coordination, scheduling deliverables, communicating with and assigning tasks to project team members, monitoring performance, and evaluation. The Smartsheet is a project management tool developed for coordinating and monitoring project activities, promoting productive guidance, efficient communication, appropriate supervision of the project team, optimization of the necessary allocated inputs, and their application to meeting the program's objectives. The paper describes the effectiveness of the team as we utilized project management tools in managing this large group of STEM projects over the past three years. Additionally, the paper elaborates on the social management theoretical framework on which the project management principles are hinged. The impactful outcomes of the STEM program in increasing academic performance as well as improving key constructs associated with student success such as motivation, epistemic and perceptual curiosity, engineering identity, and self-efficacy through the team effectiveness metrics and the results of the Strength, Weakness, Opportunities, and Threats (SWOT) analysis presented in the paper revealed an efficient management strategy anchored on the social management theoretical framework and facilitated by the project management tool.

Introduction

STEM projects in academia are centered on science, technology, engineering, and mathematics. Some of these projects are based in one of the fields, while others cut across more than one discipline. Managing such multidepartment STEM projects can be overwhelming, complex, and challenging, necessitating effective organization and collaboration between multiple teams and stakeholders [1]. Most such multidisciplinary projects are funded to drive cross-cutting knowledge acquisition and sharing, including developing tools that can be used in different fields. Hence, without proper documentation and management of such projects, achieving overall objectives can be underpinned.

To aid the successful management of complex or multi-departmental projects in fields outside the university, various social management frameworks and program management tools have been developed, employed, and reported. Aside from promoting teamwork and communication, smoothing decision-making and problem-solving, and enabling transparency and accountability, PM management processes and tools are strongly related to project success [2],[3]. These tools are designed to support the successful execution of projects by providing a range of features and functionalities that help plan, organize, and control project activities. They also offer a range of benefits to project managers, especially principal investigators (PIs) in STEM, science, technology, engineering, art and mathematics (STEAM), and other academically funded projects, including improved communication and collaboration, enhanced visibility and transparency, and more efficient resource management.

In the context of large multidepartment STEM projects, where the coordination and collaboration of multiple teams and stakeholders are critical, project management tools can be important in supporting project success. However, there is a dearth of literature on how these frameworks and tools are being utilized in practice, especially in projects carried out among academic professionals, and whether they effectively promote project success.

This study addressed this gap by investigating the utilization of social management theoretical frameworks and program management tool in a real-world case study of a large multi-departmental STEM project. This was to assess the team's effectiveness as well as identify any challenges or limitations that need to be addressed.

Literature Review

Overview of project management

A project is a combination of tasks that must be executed to achieve an outcome. For this desired outcome to be achieved, the tasks alongside the individuals and groups assigned to the tasks must be properly managed. Hence, project management can be seen as the structure that helps to guide the team's activities from project planning to finalization. Newton [4], in a systematic literature review of project management tools and their impact on project management effectiveness, revealed that the functional organizational model was more effective when managing distinct departments.

Projects are a keyway to create value and benefits in organizations, and effective project management helps individuals, groups, and public and private organizations to (1) meet business objectives; (2) satisfy stakeholder expectations; (3) optimize the use of organizational resources; and (4) manage change in a better manner [5].

Project management lifecycle

To initiate, plan, control, and conclude unique endeavors, project management (PM) tools, strategies, and processes have evolved into a professional management discipline. Corporate companies favor PM practices and tools because they are a good fit for today's quickly evolving business environment [6]. The Project Management Institute identifies five (5) processes/phases involved in managing any project. These processes are project initiation and the commencement phase, where the project manager meets with the project's key stakeholders to discuss its objectives, development, and division. Project planning is the selection phase for members, roles, and responsibilities. The execution phase, where the plans are implemented, progress is shared, and communication is at its most crucial stage. The monitoring and controlling stages are where activities are kept under strict surveillance, performances are measured against the key performance indices earlier drafted, and the last is the stage where the project is officially terminated due to the finalization of all deliverables.

Personnel management in project management

For any project to succeed, the human resources involved in its management must be properly understood. A mastery of persons involved in a project in terms of their competence

(educational background, soft and hard skills) and experience (professional experience, technical know-how, etc.) will guide the Project Manager in the assignment of roles and the actual management of the personnel vis-a-vis their deliverables. Personnel management in a project-based organization differs from personnel management in a classic organization, where getting the right people for the right tasks are contingent on the human resources management policies and practices in place. In a classic organization, getting the same in a project-based organization is based on an informal networking pool, using grapevines and temporary appointments for on-the-job training and assessment [7].

Project managers are naturally task-oriented, and their projects run for the short term; therefore, they are not keen on other aspects of personnel management that their classic counterparts will hold as sacrosanct. While the former hammers on immediate deliverables, the latter is more concerned about manpower planning because of its longer duration. The other aspects misconstrued as unimportant are the enticements leveraged by personnel managers to retain personnel.

Leadership styles

Situational: This style requires the leader to be flexible and choose the right style based on the circumstances and the relationship the leader has with subordinates. Situational leadership is best suited for leading teams where the leader has extensive knowledge and experience with each team member.

Path-Goal: In this form of leadership, the leader's traits, skills, and competencies determine the subordinates' performance and motivation. It is best used when there is a need to increase effectiveness and efficiency and provides motivation within a group [8].

Transformational: In transformational leadership, leaders strive to inspire and transform their followers by appealing to their ideals and emotions. This kind of leadership style is best suited where a need for a change in vision, process, or culture is necessary [9].

Teamwork and productivity

Understanding and maximizing the skillsets of team members will ensure that resources are used effectively. To have a productive team, team members must work in synergy and complement each other.

Tools that Aid Effective Personnel Management

Personality tests

The personality test is an assessment tool designed to understand the make-up of a person in terms of traits, likes, dislikes, areas of strengths, weaknesses, and patterns of thoughts. It is the consistent differences existing between two people that can either be inherent or learned. This set of tests seeks to unravel the unique set of drives, attitudes, emotional patterns, opinions, etc., responsible for people's behavioral patterns across various situations.

Personality tests vary depending on the purpose of their conduct. According to Littauer [10], "when we know who we are and why we act the way we do, we can begin to understand our inner selves, improve our personalities, and learn to get along with others". Consequently, personality tests can be conducted for self-understanding, personality classification (operation within the behavioral boundary inherent in a person), prediction (guessing a response/reaction), diagnosis, job screening, etc.

Personality tests are divided into four basic profiles and further divided into four profiles. Along the basic divide are introversion or extraversion, sensing or intuition, thinking or feeling, and judging or perceiving.

SWOT analysis

SWOT, an acronym for strengths, weaknesses, opportunities, and threats, identifies the strong points and deficiencies innate in people [11]. SWOT analysis results present opportunities for personality improvement for persons to self-understand and self-improve. The initial two variables of the acronym, Strength, and Weakness are intrinsic and can be derived from personality tests and controlled within, while the other two, opportunities and threats, are extrinsic.

Recognizing strength should intentionally engender exhibition and enhancement while identifying weakness should precipitate a downplay and deliberate depletion of attributes. The intrinsic variables are precursors to the extrinsic variables, as strengths engender opportunities, while weaknesses foment threats.

Theoretical Framework

Social management theoretical frameworks are approaches to management that focus on the role of social interactions and relationships in shaping organizational performance. These frameworks view organizations as complex social systems influenced by various internal and external factors, including power dynamics and communication patterns. In the context of large multidepartment STEM projects, they may be particularly useful in promoting project success.

Sociotechnical theory

The sociotechnical theory framework expresses the interdependency of an organization's social and technical aspects to understand its design and performance. The social and technical aspects must be brought together and treated as invaluable. It further posits that the organizational system is at its prime when there is a joint optimization of its social and technical aspects [12]. It is a set of explicit concepts designed to optimize people, technology, organizations, and all other systemic aspects simultaneously (Figure 1). It is inspired by general systems theory. Walker et al. [13] emphasized a crucial set of fundamental sociotechnical principles, including responsible autonomy, flexibility, and task significance. These sociotechnical concepts foster shared awareness, agility, and self-synchronization through peer-to-peer interaction, effects-based operations, semiautonomous groups, enhanced tempo, and self-synchronization (joint optimization and synergy).

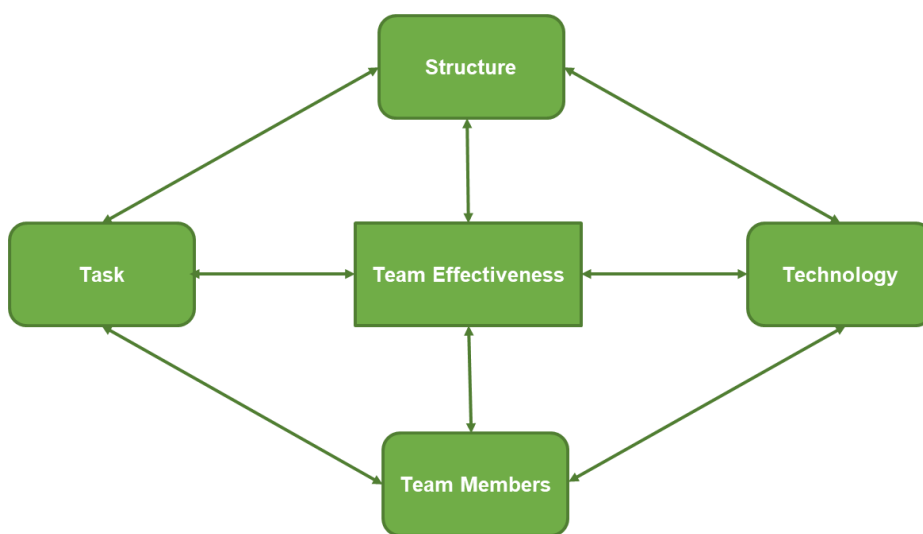


Figure 1: Sociotechnical Framework

Adaptive structuration theory

Adaptive structuration theory (AST) is a framework that explains the use of technology in organizations, how it affects organizational processes and the overall effect on organizational performance. In the words of Turner, Morris, and Atamenwan [14], AST accounts for the duality of humans and technology in organizational structures and operations (Figure 2).

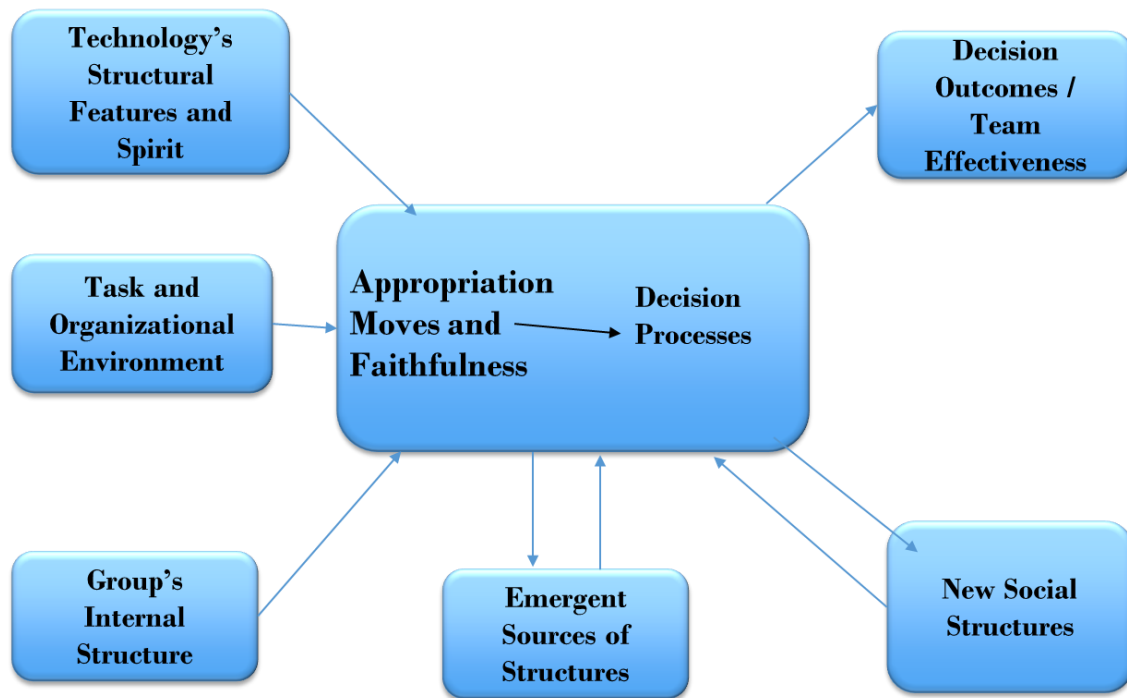


Figure 2: Adaptive Structuration Theory

Project Management Software Tools

Project management software tools are utilized to facilitate team collaboration, management and coordination of project tasks, communication among team members, and monitoring of project progress. The features of three commonly utilized project management software tools are briefly described below.

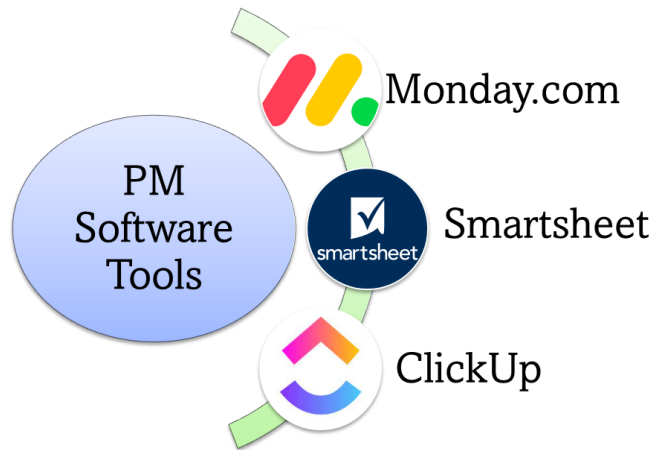


Figure 3: Project Management Software Tools

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This is a flexible platform that manages all team projects, processes, and workflows in a single platform. While the platform is intuitive and visually stunning, it is robust enough for large organizations to manage their work across departments [15]. It enables every team member to see what tasks are still on the table, where they are holding in a project timeline, approaching deadlines, and other relevant information. It allows team members to share files, add comments and communicate directly with the task manager for ultimate transparency and collaboration. Merits include the facilitation of multiple view choices, task assignment, and management and task progress with detailed, visual projects, while the major shortcoming is its high cost.

Smartsheet

Smartsheets are dynamic enterprise platforms that empower organizations and teams to dynamically plan, execute dynamically, and report on work at scale, resulting in more efficient processes, innovative solutions, and better business outcomes. The platform provides a flexible solution that facilitates adaptation to the changing needs of dynamic work across a broad array of departments and uses cases. Merits include the availability of grid, kanban, Gantt, reports, dashboards, and customizable templates. Automated updates and approval requests are other special features, while shortcomings are steep learning curves and fewer collaboration tools.

ClickUp

ClickUp is a management tool with great visualization capacity, including Gantt charts, mind maps, and Kanban boards. It also facilitates the integration of an enormous variety of software. Merits include wide visualization options, an extensive integration library, and unlimited project storage on paid plans. Shortcomings are mainly storage and board limitations on free tiers.

Materials and Methods

To demonstrate the team's effectiveness and positive outcomes of the efficient management strategy adopted, which is anchored in the social management theoretical framework and facilitated by the project management tool, a team effectiveness instrument developed by Sharif and Nahas [16] was adopted and utilized. The instruments measure fifteen team effectiveness characteristics: (1) clear purpose, (2) appropriate culture, (3) distinct roles, (4) suitable leadership, (5) relevant members, (6) adequate resources, (7) commitment, (8) cohesion and trust, (9) flexibility, (10) coordination, (11) communication, (12) decision making, (13) conflict management, (14) social relationships, and (15) performance feedback. A SWOT analysis of the team was also carried out. This study was conducted among an interdisciplinary research group at one of the historically black colleges and universities (HBCU). The research group has been a team for more than three years and has been able to work together to realize the team's goals. Participation in this survey was voluntary among the team members, and anonymity of views was ensured. The project is an experiment-focused hands-on teaching pedagogy intervention developed to promote motivation and academic achievement across seven STEM disciplines. The project is also a large educational program with multidepartment STEM projects comprising 200 tasks and 40 personnel. To facilitate the successful implementation of the multidisciplinary STEM program, an efficient project management tool called Smartsheet was adopted to manage all the tasks to be carried out and the activities involved. Smartsheet helped to facilitate efficient project coordination, scheduling deliverables, communicating with, and assigning tasks to project team members, monitoring performance, and evaluation.

The questionnaire survey comprising the team effectiveness audit tool and the SWOT analysis instrument [17] was administered among the 40 members. Responses from survey were cleaned and analysed. Descriptive statistics such as frequency, percentage, and barcharts

were used as well as mean and standard deviation. The quantitative data analysis was done using IBM SPSS Statistics (25.0), and the qualitative responses were processed through inductive content analysis using Atlassian (Figure 4).

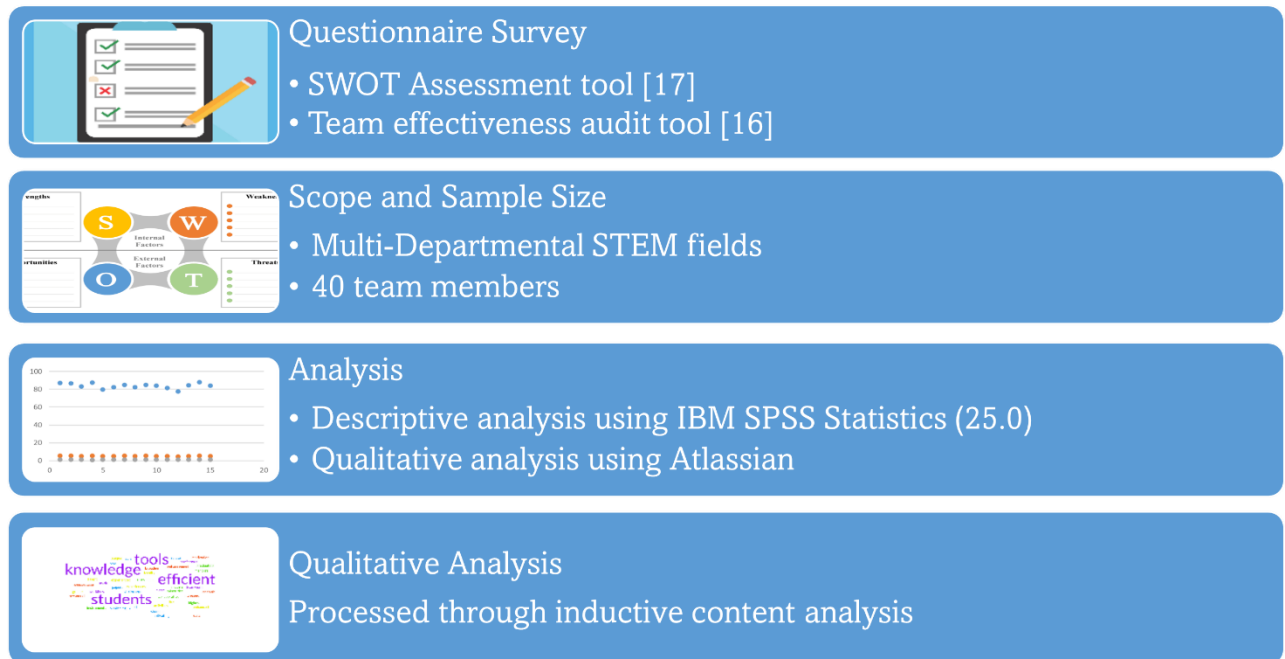


Figure 4: Methodology Adopted in the Study

Results and Discussion

Team Characteristics

Among the 40 members, 27 responses (62.5%) were obtained, and all were found to be fit for the data analysis. The demographic profile is presented in Table 1. The results show that 70.4% of the participants were males and 29.6% were females (Figure 5). The team consists of the principal investigator (3.7%), co-principal investigators (7.41%), faculty members (44.44%), and graduate researchers (44.44%) (Figure 6). The team was a mix of participants from different STEM fields, as shown in the results presented in Table 1.

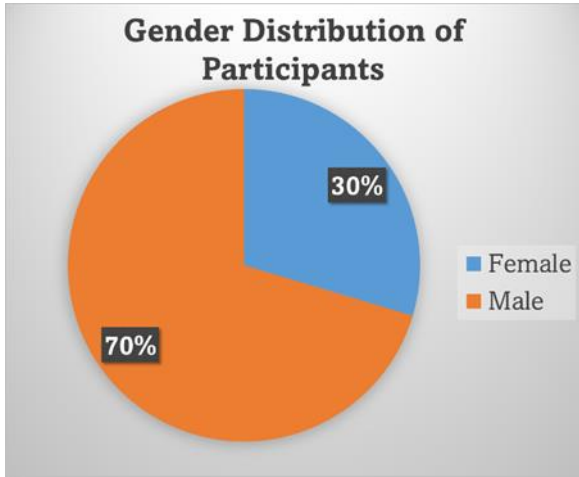


Figure 5: Gender Distribution of Participants

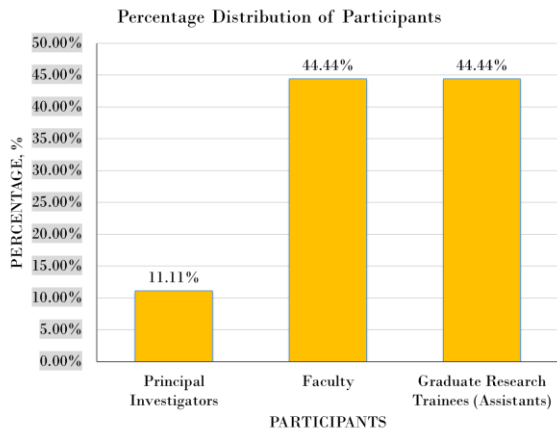


Figure 6: Percentage Distribution of Participants

Table 1: Demographic Characteristics of the Team

Variables	Frequency (N=27)	Percentages, %
Gender		
Female	8	29.6
Male	19	70.4
Role		
Principal Investigators	3	11.12
Faculty	12	44.44
Graduate Research Trainee (Assistant)	12	44.44
Department		
Biology	3	11.1
Chemistry	4	14.81
Civil Engineering	6	22.22
Computer Science	2	7.41
Education	3	11.11
Industrial Engineering	1	3.70
Mathematics	1	3.70
Physics	2	7.41
Transportation	4	14.81
Others	1	3.70

Team effectiveness characteristics

The percentage of responses of the participants on team effectiveness is presented in Table 2a-c. The majority, 62.97%, strongly agreed that clear objectives are established for team activities. Moreover, 51.85% strongly agreed that the team members are supportive of each other, and 40.74% agreed that the team members feel fully utilized. In summary, the results

showed that larger percentages of the respondents agreed with all of the items. Additionally, it was observed that the highest percentage of disagreement in some items was 7.41% and occurred under “The team often reflects on how well they achieve the objectives” and “the team is involved in creating task objectives.”

Table 2a: Percent Responses of the Participants

	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly agree (%)
The team is aware of the organizational objectives and is committed to achieving them	0.00	3.70	0.00	3.70	29.63	62.96
There are clear objectives established for team activities.	0.00	3.70	0.00	0.00	33.33	62.96
The team often reflects on how well they achieve the objectives	0.00	7.41	0.00	3.70	33.33	55.56
Team members are supportive of each other.	3.70	0.00	0.00	7.41	37.04	51.85
Team members are always friendly	3.70	0.00	0.00	0.00	33.33	62.96
The team is involved in creating task objectives	0.00	7.41	0.00	18.52	25.93	48.15

Table 2b: Percent Responses of the Participants

	Strongly disagree (%)	Disagree (%)	Somewhat disagree (%)	Somewhat agree (%)	Agree (%)	Strongly agree (%)
Members are clear about their roles in the team	0.00	3.70	0.00	11.11	37.04	48.15
There is effective and appropriate leadership within the team.	0.00	3.70	0.00	7.41	25.93	62.96
Members of the team feel that they are fully utilized.	3.70	3.70	0.00	14.81	40.74	37.04
The team has the resources it needs to do the job and meet the targets it has been set	3.70	0.00	0.00	14.81	40.74	40.74
When things at work are stressful, we pull together as a team.	0.00	3.70	3.70	14.81	25.93	51.85
All individuals are committed to perform to the best of their ability within the team	0.00	3.70	0.00	11.11	22.22	62.96

Table 2c: Percent Responses of the Participants

In this team, we modify our objectives in the light of changing circumstances.	3.70	0.00	0.00	18.52	33.33	44.44
The methods used by the team to get the job done are often discussed.	0.00	3.70	3.70	7.41	29.63	55.56
There is effective communication within the team.	0.00	3.70	3.70	7.41	37.04	48.15
Individuals feel valued as members of the team.	0.00	3.70	0.00	14.81	40.74	40.74
Morale within the team is high	3.70	3.70	0.00	11.11	44.44	37.04
The way decisions are made in this team is often reviewed.	3.70	3.70	3.70	18.52	37.04	33.33
Conflict does not linger because people in this team are quick to resolve arguments	0.00	3.70	0.00	14.81	29.63	51.85
Individuals feel proud to be a member of the team	3.70	0.00	0.00	3.70	25.93	66.67
Performance is monitored, and feedback is given on a regular basis.	3.70	0.00	0.00	11.11	37.04	48.15

To determine the effectiveness of the management strategy utilized and the efficacy of the management tool, a percentage of all scores for each characteristic is divided by the maximum possible score (6) and then multiplied by 100. A Cronbach's alpha test for reliability is performed to check the internal consistency of the characteristics included in the questionnaire. However, some constructs have just one variable, and Cronbach's alpha could not be evaluated.

The overall percentage score of responses from the participants ranged from 77.38% (decision-making) to 88.10% (social relationships) (Figure 7 and Table 3). According to

Mealica and Baltazar [18], the range of scores indicates that the interdisciplinary team is effective. Social relationships had the highest percentage and mean score (5.48), which suggests a level of mutual relationship among the team. However, decision-making was the lowest score among the participants and thus further buttressed the lack of distinct roles. When decision-making is not well clarified within an organization, Zaccaro et al. [19] mentioned that process losses would be predominant, affecting overall productivity and sponsor delays in the timely delivery of project deliverables. Figure 8 shows the team’s core competencies.

To determine participants' level of agreement on some of the constructs, Cronbach's alpha was used as the determination tool. The range of Cronbach's alpha in the study was 0.52 as the minimum and 0.91 as the maximum. This revealed a high level of agreement in the participants' responses aside from the distinct role construct. This implies that among the participants, a larger proportion has cross-cutting roles.

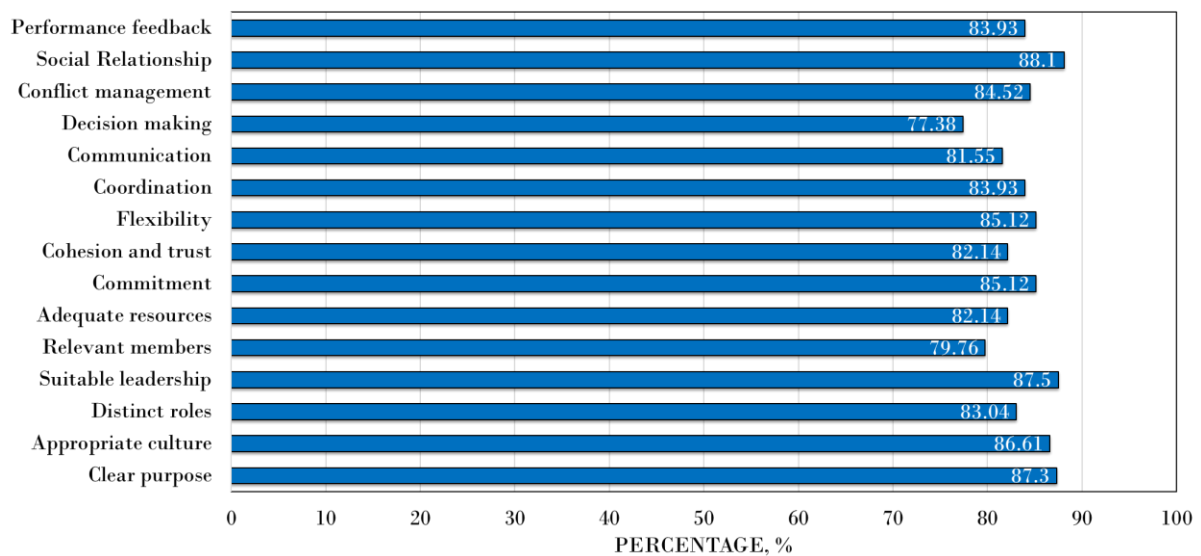


Figure 7: Summary of Overall Team Effectiveness

Team's Core Competencies

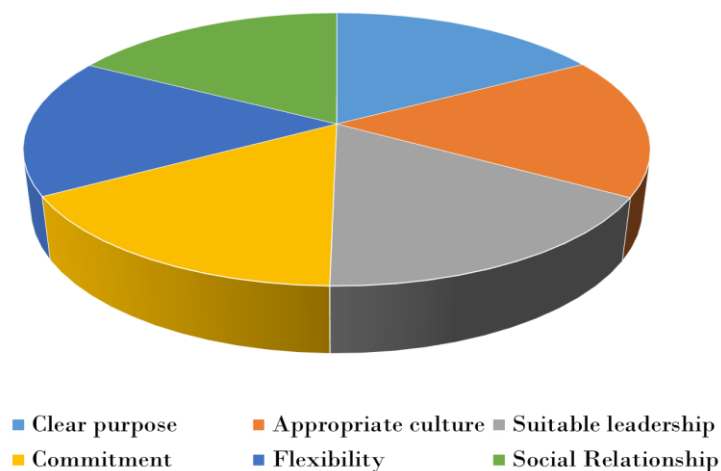


Figure 8: Team's Core Competencies

Table 3: Overall Team Effectiveness

	Percentage	Mean	SD	Cronbach alpha
Clear purpose	87.30	5.43	0.95	0.91
Appropriate culture	86.61	5.39	1.04	0.90
Distinct roles	83.04	5.17	1.06	0.52
Suitable leadership	87.50	5.44	0.93	-
Relevant members	79.76	4.96	1.22	-
Adequate resources	82.14	5.11	1.09	-
Commitment	85.12	5.30	1.02	0.74
Cohesion and trust	82.14	5.11	1.12	-
Flexibility	85.12	5.30	1.03	-
Coordination	83.93	5.22	1.01	-
Communication	81.55	5.07	1.08	0.83
Decision making	77.38	4.81	1.27	-
Conflict management	84.52	5.26	0.98	-
Social Relationship	88.10	5.48	1.05	-
Performance feedback	83.93	5.22	1.09	-

Team SWOT Analysis

A team member used a deductive approach to analyze the open-ended questions, guided by the SWOT analysis method. Some of the open-ended questions asked were as follows: What unique knowledge, talent, or resources do we have? What do other people say we do well?; what is our greatest achievement?; What knowledge, talent, skills, and/or resources are we lacking?; What complaints have we had about our project?; and How is our field changing? How can we take advantage of those changes? Can any of our weaknesses prevent our unit from meeting our goals? The major themes were derived from the SWOT analysis method: strengths, weaknesses, opportunities, and threats (SWOT). Excerpts of responses that were classified as strength themes are “clear goals”; “very efficient workflow”; “teamwork with professors and students”; “motivating students”; “publishing good papers”; “able to relate to our student challenges and being role models and mentors”; “graduating the highest no of minorities”; collaborative tools, assessment tools, instruments, experienced faculty; we have unique talent, knowledge and experiences of efficient and enhanced Lab Activities; our greatest achievement is personnel enhancement; “increased motivation”; “broaden my knowledge of data analysis”.

Sample excerpts of responses that were classified as weakness themes are “not enough money to hire more students and faculty or staff”; “finding classroom with necessary resources”; “lack of outreach to schools and retraining of teachers”; “not adapting to the evolving technologies” “proper sensitization of new graduate students of their roles and responsibilities”; “keeping every team member accountable” “time management”; “we can improve in better coordination and training of personnel”; “hiring dedicated technical personnel”; “lack of adequate research data”; “human capital, hardware, and software resources.”

Additionally, some sample excerpts of responses that were classified as themes for opportunities are “good management”; “research skills and unity”; “quality and well-detailed experiments”; “outreach to feeder schools and private sector participation”; “maximizing and synergizing the capacity of team members”; “introduction of updated technology being used”; “effective writing, exhibitions, conferences, publishing papers”; “team work, willing to help hands”; “teams can be built up for diverse areas of research such that diverse research

areas can be competed for at the same time”; “this will enable multiple grantsmanship within the same window”; “problem-solving skills, human resources, and leadership”; “diversity in different fields of STEM”; “diversity, inclusion, and experienced researchers, mentorship”; and “participants who have a diversified background and talent have been working together for the same goal.”

Examples of statements from the responses that were classified as the threat theme are “homefront issues affecting our students”; “getting more support from the government, like sponsorship”; “be able to continue for another year with great results”; “increased student interest in learning and understanding the complexities of STEM subjects”; “a backup financial aid for new members before they are enrolled in the payroll program”; “retrain faculty and staff to be market-oriented”; “low Stipend”; “Retaining team members till the end of the project”; “students computer not compatible with the software” “GAs not performing their duties as at when due”; “advancing technology; being adaptive to changes”; “team members' retention and activity delivery”; and “writing skills and documentation can be improved on.”

The overall team's strengths, weaknesses, opportunities, and threats were analyzed to demonstrate the actualization of project outcomes and the acquisition of appropriate feedback that will facilitate entire project management improvement (Figure 8).



Figure 8: Summary of Team SWOT Analysis

Conclusion

This study was carried out to understand the impact of the social management framework and project management tools on the overall management and effectiveness of an interdisciplinary research group as well as the SWOT analysis of the team. The study hinged on presenting characteristics that can support the organization, management, and effectiveness of large multidisciplinary research groups after a careful discovery of a dearth of literature in the area. Collaboration in research projects tends to come with attendant challenges but by employing project management tools and the leadership equipped with the understanding of social-management theory, the present study posited finding a highly functioning and effective team. This was done by investigating the team's effectiveness, and a SWOT analysis was conducted. Overall, the team was found to be more effective in social relationships, conflict management, suitable leadership, commitment, flexibility, and a notable level of clarity of purpose. From the qualitative data, it is evident that the strengths and opportunities of the theme outweighed the weaknesses and threats. Several questions such as ‘what knowledge, talent, skills, and/or resources are we lacking? what complaints have we had about our project?’ yielded “None” as responses from most of the respondents. Additionally, the respondents indicated optimism that threats could be turned into opportunities and weaknesses could be transformed into strength with sustained team spirit and if worked on each specific threat and weaknesses deliberately.

Acknowledgment

This study is part of the work that was supported by the National Science Foundation Grant # 1915615 titled “Adapting an Experiment-centric Teaching Approach to Increase Student Achievement in Multiple STEM Disciplines”. It should be noted that the opinions, results, conclusions, or recommendations expressed are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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