MANAGEMENT OF ENGINEERING TEAMS

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Purpose: The aim of the paper is to analyze the methods of management in the case of engineering teams.

Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

Findings: The considerations presented in the publication made it possible to analyses the most important aspects of managing engineering teams. The publication draws attention to the specificity of managing engineering teams and the features that distinguish it from management in other types of organizations. In particular, it points out how to develop engineering teams in subsequent stages. The paper presents soft skills that should characterize people managing engineering teams, such as: dependability, work ethic, communication skills, community and teamwork, time management skills, goal setting, mental ability and takes direction well. The paper has a special focus on the best practices that should be followed to effectively manage engineering teams. Especially nowadays, in the era of Industry 4.0, there is a need for team management in industrial companies as well as more and more cooperation between people and machines. This kind of approach requires careful planning and management of engineering teams. The best practices presented in the publication can provide assistance to engineering teams in today's industrial enterprises wherever teamwork is necessary.

Originality/value: Detailed analysis of all subjects related to the problems connected with management of engineering teams.

Keywords: teams, management, motivation, organization, human resource management, Industry 4.0.

Category of the paper: literature review.

1. Introduction

It is not easy to give a process definition of term management. Different authors have different approaches to this concept. Every specialist put attention on another part of the management concept (Gębczyńska and Wolniak, 2018; Grabowska et al., 2019; 2020; 2021; Wolniak and Skotnicka, 2011; Wolniak and Skotnicka-Zasadzień, 2008). Examples of useful definitions of the term management are (Geffen, 2020):

Management is the art of getting things done through and with people in formally organized groups.

Management is a disconnect process consisting of planning organizing activating and controlling performed to determine and accomplish the objectives by the use of people and resources. Management is the art and science of decision making and leadership (Hąbek and Wolniak, 2013; 2016; Hys and Wolniak, 2018).

Good Management, or scientific management, achieves a social objective with the best use of human and material energy and time, and with satisfaction for the participants and the public (Wolniak and Skotnicka-Zasadzień, 2010; 2018; 2022; Wolniak et al., 2019; Wolniak and Sułkowski, 2016).

To manage is to forecast, to plan, to organize, to command, to coordinate, and to control.

Management is a social and technical process which utilizes, resources, influences, human action and facilitates changes in order to accomplish organizational goals.

The aim of the paper is to analyze the methods of management in the case of engineering teams.

2. Classic functions of management

The need for management in business world normally arises when group of people come together to tackle a task that is too large or too complex for any individual to cope with (Humphrey et al., 2009). In industrial organization it's normal that we are faced with such situation (Gajdzik and Wolniak, 2021). In this situation we need to break tasks or problems down into key elements traditionally involved key management practices for example: planning, organizing, staffing, directing, coordinating, reporting and budgeting (Thomas, 2007). We described the main managerial activities in the table 1.

Table 1.
Classic functions of management

Function	Characteristic
Planning	Planning involves establishing the main objectives or outcomes of the work. It entails detailing the tasks that need to be achieved and the methods for accomplishing them. Planning provides a strong focus and framework for any project or task.
Organizing	This function involves establishing formal structures of authority so that tasks and activities can be defined and co-ordinated amongst the people involved. Organizing also includes the selection and training of staff to deliver the objectives.
Directing	Making effective decisions in a timely and appropriate manner. Creating a shared understanding of the key goals and objectives through the use of appropriate communications channels.
Forecasting	Estimating future needs and requirements. For example, market growth, market share, customer demand, profit and revenue streams, return on investment etc.
Establishing objectives	Establishing the results that have to be achieved.
Scheduling	Establishing the priorities and sequence of actions needed to achieve the stated objectives. What is the order in which tasks and initiatives need to happen?
Budgeting	Allocating the necessary resources to deliver the objectives and outcomes – people, equipment and finance.
Establishing procedures	Developing and applying standardized methods and processes for executing the work.
Selecting the team	Identifying the right people with the right skills for the tasks and roles to be performed.
Delegating	Allocating the appropriate levels of responsibility and accountability to people.
Motivating people	Energizing people on a collective basis and leading them to deliver high levels of performance even when faced with setbacks and obstacles.
Developing people	Advising team members on how they can fully develop their skills and capabilities to increase their value and realize their full potential.
Leading	Involves working with and through people to accomplish organizational goals. Leading involves the social and informal sources of influence that you use to inspire action taken by others. If managers are effective leaders, their subordinates will be enthusiastic about exerting effort to attain organizational objectives. The behavioral sciences have made many contributions to understanding this function of management. Personality research and studies of job attitudes provide important information as to how managers can most effectively lead subordinates.
Controlling	This function involves monitoring any work in progress so as to ensure results are ultimately delivered. It entails inspecting projects and work plans and driving any financial planning, accounting or controlling procedures. The function also involves advising and reporting to senior managers on progress.

Source: own work based on: (Thomas, 2007; Mustafa, 2022).

Today the high level of competition lead to emphasis on highly performed organization and highly performed managers (Gajdzik and Wolniak, 2022). They may be summarized by following points (Miller, 2022):

- High acceptance of responsibility for business performance at every level.
- High information access and sharing.
- Regular and rigorous process measurement and analysis.
- High contact with customers and focus on their requirements.
- Flexibility and adaptability to changing markets and technology.
- High teamwork at every level of the organization.

A team can be defined as a unified group of people with a common goal or purpose and identity (Jonek-Kowalska and Wolniak, 2021; 2022; Jonek-Kowalska et al., 2022). Each team member is committed to working together and has their own areas and responsibility and accountability (Bang, 2017). In effect they need each other in order to succeed (Barakat, 2011). Any industrial engineer manager in today fast changing business environment needs to be able to form teams quickly and create an atmosphere of strong and productive working relationships (Drozd and Wolniak, 2021; Kordel and Wolniak, 2021' Kwiotkowska et al., 2021; 2022; Orzeł and Wolniak, 2022; Ponomarenko et al., 2016). To help a team to function properly and effectively the leader needs to provide the following points (Thomas, 2007):

- Clear objectives and roles for the team and individual members.
- An informal but effective working atmosphere.
- Time-lines and control processes for guiding the team.
- Regular assessments of both team and individual performance.
- Rewards for performance – both for the team as a whole and individuals.
- Development and coaching to continually raise performance standards.

The model of forming engineering team invented by Tuckman is based on four sequential stages of developing all teams experience (Thomas, 2007; Jones, 2019):

- forming stage,
- storming stage,
- norming stage,
- performing stage.

Table 2.
The four stages of developing an engineering team

	Forming stage	Storming stage	Norming Stage	Performing stage
General observations	Uncertainty about roles, looking outside for guidance.	Growing confidence in team, rejecting outside authority.	Concern about being different, wanting to be part of team.	Concern with getting the job done.
Content issues	Some attempt to define the job to be done.	Team members resist the task demands.	There is an open exchange of views about the team's problems.	Resources are allocated efficiently; processes are in place to ensure that the final objective is achieved.
Process issues	Team members look outside for guidance and direction.	Team members deny the task and look for the reasons not to do it.	The team starts to set up the procedures to deal with the task.	The team is able to solve problems.
Feeling issues	People feel anxious and are unsure of their roles. Most look to a leader or coordinator for guidance.	People still feel uncertain and try to express their individuality. Concerns arise about the team hierarchy.	People ignore individual differences and team members are more accepting of one another.	People share a common focus, communicate effectively and become more efficient and flexible as a result.

Cont. table 2

Behavioral characteristics	• Politeness. • Superficiality, reserved. • Avoiding controversy. • Suspense – what's going to happen to me? • Withholding of information. • Watchful of other members – guarded position. • Relatively low levels of involvement and participation. • Fear, anxiety, nervousness.	• Feeling stuck: "What are we supposed to be doing here?" • I'm fed up with this" feelings being expressed. • Opting out of proceedings. • Resistance to requests for help and co-operation. • Competitive behavior between team members. • Sub-groups developing. • Jockeying for position – who's in charge here? • Differences being expressed openly.	• Give and take amongst team members. • Acceptance and agreement on roles and responsibilities. • Procedures and processes understood by all. • Ground rules for meetings are set and adhered to. • Working together. • Group decision-making is generated by quality discussions. • Increased levels of active listening occur.	• High performance and productivity through problem solving • Strategies. • Strong mutual support and co-operation. • Giving and re-ceiving feedback. • Lots of emotional and task support evident in team working. • Follow through with regard to commitments and action plans. • Strong team identity, spirit, pride and cohesion. • All team members contribute. • Flexibility in outlook and approach. • Compliance of the norming stage is replaced by commitment.
Strategies to help a team move through this phase	• Establish a clear sense of direction and performance goals. • Identify the resources available to the team. • Effect introductions – 'break the ice' and get people co-operating. • Build a supportive and open atmosphere. • Identify relevant parties and stakeholders outside the team. • Clarify individual roles, expectations and objectives. • Get the team doing things together.	• Allow the dispute to continue for a while – the team need to vent – it is OK! • Re-establish and confirm the team's mission and objectives – why we are here. • Clarify the leadership role. • Clarify roles, responsibilities and expectations. • Promote real listening amongst the team. • Establish required team procedures and processes. • Provide positive feedback. • Manage the conflict constructively – identify the issues.	• Demonstrate 'give and take' amongst team members. • Discuss team processes and dynamics. • Ask for input versus 'telling'. • Focus on team goals and objectives when conflicts arise. • Demonstrate openness to feedback. • Re-establish roles and responsibilities. • Confront issues.	• Delegate, coach and develop team members. • Enhance openness. • Promote supportive and creative confron-tation of ideas. • Seek out feedback. • Let go!

Cont. table 2

		• Stay relaxed and calm – see this stage as natural and positive. • Move the team from 'testing and proving' to a 'problem solving • mentality'.		
The team leadership issues	• Dependence on the leader to get things moving. • Providing direction: moving the team from the comfort of non-threatening topics to encountering the risk of disagreement and potential conflict.	• Feelings of loss of control. • People opt out or drop out. • Loss of momentum and impetus. • Challenging the leader. • Resistance to move things on.	• Inter-dependence between members and the leader. • Sharing and completing work together. • Shaping the team as an effective unit.	• Inter-dependence of the team and leader. • Role of the leader – redundancy?! • Need to stand back – delegate and empower.

Source: Own work based on: (Thomas, 2007; Bruce, 2022; Rickard and Moger, 2000; Bonebright, 2010).

Every manager should have proper managerial skills which are indispensable if he wants to achieve his goals and be successful (Stawiarska et al., 2020; 2021; Sułkowski and Wolniak, 2016; 2018; Wolniak and Sułkowski, 2015). Every manager should focus on three dimension in his work (Jitesh, 2022; Jones, 2019):

- technical – an understanding of proficiency in engineering and science,
- human – the ability to build a collaborative effort within a group,
- conceptual - he ability to apply analytical thought to the management process and to enterprise as total system.

3. Soft skills for engineers managing teams

Engineering managing teams should have not only technical skills but also it very important he have also so called soft skills (Wolniak and Skotnicka-Zasadzień, 2014; Wolniak, 2011; 2013; 2014; 2016). We described in the table 3 the most important soft skills needed by engineers when they manage teams.

Table 3.
Soft skills for engineers managing teams

Skill	Characteristic
Dependability	Can you be depended on to be where you need to be, to do what needs to be done, to do what you say you will? Your boss must be able to depend on you or you will not get ahead. It is equally important that your peers and your subordinates believe they can depend on you too. Without that, they will not give you the support you need if you are going to be successful.
Work ethic	You were hired to do a job. Do you do it or do you sit back and watch others work? Are you the hardest working person in your group? If not, you ought to be. We described the problem connected to engineering ethic in the chapter 4 of this book.
Communication skills	How well do you communicate with your boss, your peers, your subordinates? Are you able to communicate as well in writing as you are verbally? If you have any weakness in this area you need to work to improve or to eliminate it.
Community and teamwork	A lot has been written about the need to demonstrate your ability to work well with the other members of your team. It is a skill that is becoming more important as we move toward more cross-functional teams. But it is also important that a manager build community. Don't just be part of your team, but understand how it fits in the larger organization and work to strengthen those connections.
Time management skills	The one resource a manager will never have enough of is time. To succeed as a manager, it is vitally important that you develop, and continually improve your skill, in time management. In addition to the ability to prioritize and to delegate, which reduce the number of things you have to do, you have to be able to maximize what you do get done in the time you have
Goal setting	Good managers are able to determine what needs to be done and to set goals to get there. Don't just drift through the day dealing with what lands on your plate. Prioritize. Figure out what needs to be done and set specific goals for yourself and for your team
Mental ability	When hiring, one always look for the candidate who is one step ahead of other in the interview because that person will be the same way when hired. These people catch on quick. They understand business in general and their industry in particular. They are critical thinkers and problem solvers.
Takes direction well	As much as manager are valued for their ability to figure out what needs to be done and get after it, there are still times when they need to be told to do something. Whether it is a change in strategic direction or coaching regarding their performance a good manager has to be able to not only accept the directions, but to do so with a positive attitude, and learn from them.

Source: own work based on: (Jitesh, 2022).

Structuring an organization into teams should be seen as a strategic initiative to achieve operational effectiveness (Geffen, 2020). Participating in a team is not voluntary any more than other management practice (Wolniak, 2017; 2018; 2019; 2020; Wolniak and Sułkowski, 2018; Wolniak and Grebski, 2018). Team management is not merely involvement, it is empowerment. Teams are assigned authority and responsibility for a specific process and for specific performance. The high performance engineering team should meet following points (Miller, 2022; Vacchani, 2016):

- A team with clear responsibility for business performance.
- A team that knows its customers, suppliers and has a documented process known to all members.
- A team with a balanced scorecard linked to organization performance.

- A team with built in flexibility and adaptability through multi-skilled members who share functions.
- A team that has demonstrated competence at problem solving by improving their work processes.

Teams should be empowered to make decision concerning their portion of the business rather than merely making recommendation to higher level of authority (Wang et al., 2021). While team structure may change in industrial organization, and people will serve on several teams, it should be seen as a permanent fixture in the organization, not a temporary answer to a business crisis or a particular problem (Wolniak et al., 2019; Wolniak and Hąbek, 2015; 2016; Wolniak and Jonek-Kowalska, 2021; 2022; Wolniak et al., 2020). We can distinguish some main steeps in the engineering team management process. We described them in the table 4. While each team will respond to their own work process and priorities, they almost always should de described points in following order.

Table 4.
Steep of engineering team management process

Steep	Characteristic
Define Team Principles	All groups, whether families, athletic teams or work teams function well when they have common understanding priorities and principles. Define your team's principles around your organization's vision and how you want to work as a team. Principles may include things such as the agreement to conduct discussions with absolute frankness and honesty; to agree to adhere t decision in unity as if they were your own; to listen to all input with respect; and to maintain a constant focus on the requirements of customers.
Clarify Roles and Responsibilities	One of the most common misunderstandings of team management is that teams reduce responsibility and result in the chaos unclear roles. If one had never seen a basketball game and walked into the arena it might appear to be chaos with players running every which way in apparent disorder. However, the more one under-stands the sport, the more one understands that there are very clear roles and responsibilities, designed plays and discipline. The same is true with management and work teams. Roles may include facilitation, data collection and presentation, customer and supplier communication, training, and responsibility for specific process steps.
Define Key Customers and Requirements	Reports that "quality is dead" are premature. Without a doubt one of the most useful concepts to come out of the quality movement is the focus on customers and their requirements. The team management process institutionalizes this focus as a routine responsibility of every employee on every team. Each team will decide how best to define their customers and how to gather data on requirements. They may interview their customers, gather survey or telephone information, and will seek to develop ongoing customer feedback on their performance. They will also define their suppliers and share their requirements with their suppliers.
Develop a Balanced Scorecard	The purpose of the team management process is to improve business performance. Each and every team should know their data. They should define measures that reflect the output of their work process as well as measures of customer satisfaction. Measures typically include productivity, quality, costs and cycle time. It is generally the practice to develop a visual scoreboard so that every team member can see the graphs moving toward their goal and experience the emotional impact of improved (or the reverse!) performance. Scorecards are generally reviewed at each team meeting and form the basis for ongoing problem solving and performance improvement efforts.

Cont. table 4

Analyze the Work Processes	Teams are formed around responsibility for specific work processes. The processes may be assembling a certain product in a manufacturing environment, servicing a group of customers, selling to a defined market group, or for a senior management team, developing business strategy. Each team should be expert in those processes for which it is responsible. To be expert in a work process that process must be de-fined, its course mapped, its cycle time measured and alternatives considered. A requirement of ISO 9001 is that definition and management of processes. This is also a requirement of the team process. It is from this analysis and knowledge that is formed the basis for continuous improvement.

Source: own work based on: (Miller, 2022).

4. Best practices of team management in engineering

On the basis of the experiences connected with ream-management in industrial organization there is in the literature description of many practices that should be used by engineers to successfully manage their teams. In the table 5 there is an characterization of main best practices of leading teams of engineers.

Table 5.
Best practices of team management in engineering

Practice	Characteristic
Understand your team	When you take on a leadership role, you need to get to know your team members. These are the people on whom you will rely to complete a project effectively and on time. They are not mere cogs in a machine; they are individuals, and each has his or her own strengths and weaknesses. A person may be suited well for one part of the process, but flounder in another area. Part of your job is to direct the right people to the right work in order to best advance a project to completion. Leading engineers requires you to advance beyond the mechanics of a product or the processes of assessing quality and functionality.
Understand project details	Your engineering knowledge should remain your base. Before you can lead, your team members need to know that you understand their jobs. Good engineers are detail-oriented; you need to master the details to earn their respect. As their leader, you not only need to know everyone's area of expertise, but also know how each one contributes to the overall picture. Be ready to ask the right questions of team members and to answer questions on the finer points of the project. If team questions appear to be taking someone in a different direction than you need, be ready to bring them back on target.
Have confidence not to micromanage	The flip-side of knowing details is to trust your team to navigate those details. This is one of the most difficult aspects of moving into a position of leadership: moving away from doing everything and moving into managing the processes and workflows. When you delegate tasks, you give a sense of ownership to your team members. If you try to control every aspect of what they do, you set yourself up for failure. Engineering projects require collaboration and coordination; trying to keep your fingers in everything defeats the purpose. A true leader will develop reporting for the team and check in periodically, while giving team members the freedom to work independently. They will be more effective for it, and you can focus on the overall goals rather than each minute detail. To lead teams effectively, learn to put your engineers in a position to succeed--and then get out of their way.

Cont. table 5

Be flexible	A good leader manages change well. Your greatest value comes not in the planning itself, but in helping a project succeed when things do not go according to plan. Build in time for contingencies, and be ready to shift resources to ensure your timeline and end product remain feasible in the face of disruption
Keep an eye on the big picture	Engineers often do task-oriented work. As a leader, you need to see how each task affects the overall project, and how the project fits into your company's overall goals. When team members' work moves in the wrong direction, it is up to you to bring it back. You will experience hiccups and delays along the way; focusing on the end goal helps you move past those to right the ship and lead your team to success.
Communicate well	When you lead an engineering team, you need to communicate clearly. Your team members need to know what you expect of them. Company management also must understand what you are doing and why. You will deliver oral instructions and written reports, and must learn to clearly and concisely deliver the information everyone in your organization needs to know. People are generally able to adjust to almost anything. To do so, though, they must understand and appreciate what is happening and why. Your effective communication serves your team and everyone in your organization.
Manage up, down and through the finish	Understanding how to succeed begins with defining what outcomes represent success for your project. You need to set reasonable expectations for your managers to hold, and then identify those expectations for your team. Each engineer focuses on individual tasks, but to lead them through to the project's conclusion, you need them to understand not only what each task entails, but for what they are working.
Reward problem-solving	Technical people love to solve problems and build stuff. Trying to figure out what incentives can foster this fundamental characteristic can be tough. Try organizationally elevating the importance of your company's desire and ability to build great products. Products are important to your business, so you're not paying lip service. Rather, you are paying attention. Instill pride in engineers' efforts through all-hands meetings, group messages, or blogs. Another thing you can do is compensate technical staff appropriately. It's rare that technical people will complain about their pay or demand more compensation. It's far more common, especially in the Bay Area, that they'll leave for a job with better salary and more recognition.
Trust your engineers	Instead, set clear objectives and timelines, from the project level (daily, weekly, monthly) to the team level (sprints, product deadlines, market milestones). Then let them work through how to define and organize the work to meet the objectives. You'll get more energized, enthusiastic teams and better work as a result.
Share customer feedback	Technical people respond well to data. Give your team feedback on how their work is being used. But don't get stuck on the raw data, such as number of users; let them know how their work benefits customers. Spend lots of cycles talking to customers and your customer support team to gather this information. Make sure the functional teams (engineering, product, support, sales, etc.) share the feedback.
Don't overcompensate management	Create a system where technical staff don't have to become managers to grow their careers. Most companies pay management the most, on the assumption that managers should have significantly higher salaries than their staff. This greatly overvalues the contribution of managers.
Foster a sense of team and mission	Building strong, inclusive teams with cohesive social bonds takes a massive amount of forethought and work. But that forethought and work is an integral part of leading a team, because having strong teams is paramount to our success as a company. Evidence has shown time and time again that teams who work well together are happier, more productive, and retain better. Leaders should be able to instill a strong sense of mission in their teams, and those missions should be feasible and compelling. A team's mission is like a north star — it can keep that team moving in the same direction, together.

Source: own work based on: [7 best, 2022; 5 secrets, 2022; Sorenson, 2022].

5. Conclusion

The considerations presented in the publication made it possible to analyses the most important aspects of managing engineering teams. The publication draws attention to the specificity of managing engineering teams and the features that distinguish it from management in other types of organizations. In particular, it points out how to develop engineering teams in subsequent stages. The paper presents soft skills that should characterize people managing engineering teams, such as: dependability, work ethic, communication skills, community and teamwork, time management skills, goal setting, mental ability and takes direction well. The paper has a special focus on the best practices that should be followed to effectively manage engineering teams.

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