Introduction to Operation Management

010 Directing the operation

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Digital transformation

Digital transformation is a sweeping change that affects not just operations management but all aspects of business and society. It involves the integration of digital technology into all areas of a business, fundamentally changing how businesses operate and deliver value to customers. It's also a cultural change that requires organizations to continually challenge the status quo, experiment, and get comfortable with failure.

For some digital transformation experts, leadership is even more important than technology. "Many of the most effective solutions to the challenges of digital transformation don't involve technology at all. Instead, they involve rethinking leadership, rethinking talent, and rethinking organization," says Gerald Kane. (McCausland, 2021).

For operations managers, digital transformation presents both opportunities and challenges.

What is digital transformation and why is it getting more important?

Digital transformation considers a broad range of changes, including cultural, organizational, and operational transformations, by integrating digital technologies, orientation, and capabilities at all levels of organization. (Rupeika-Apoga, R.; Petrovska, K.; Bule, L., 2022). Digital transformation is not just about technology; it's also about the cultural change that organizations undergo to adapt and thrive in an increasingly digital world.

What is 'new' in new digital transformation?

The concept of "new" in digital transformation refers to the ongoing evolution and application of digital technologies that are creating novel opportunities and challenges for businesses and organizations.

This evolution is characterized by the emergence of advanced digital capabilities that are being integrated into various operations, leading to significant changes in how organizations function and compete. (Matt et al. 2015)

It is critical to get a close fit between digital transformation strategies, IT strategies, and all other organizational and functional strategies. Research has addressed this issue and has sought to consolidate IT strategies and business strategies into a comprehensive "digital business strategy" (Bharadwaj et al. 2013)

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Moravec's paradox

Moravec's Paradox, as mentioned in the context of digital transformation, refers to the observation made by AI researchers in the 1980s, including Hans Moravec, that computers find it easy to perform tasks that are intellectually demanding for humans (like playing chess), but struggle with simple perceptual and motor tasks that humans find intuitive (like recognizing objects or moving around in a complex environment). This paradox has implications for digital transformation as it highlights the areas where technology has traditionally struggled and where recent advancements are now breaking new ground. (Moravec, 1988).

> *"It is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility".*

Here's how the concept of "new" in digital transformation and Moravec's Paradox relate to each other:

1. Advancements in AI and Machine Learning:

New digital transformation efforts are leveraging advancements in AI and machine learning to overcome Moravec's Paradox. For example, AI algorithms are now capable of complex visual recognition tasks and natural language processing, which were once considered challenging for machines.

The recently advanced AI algorithms, such as deep learning (DL), have made the computer processing of perceptual and cognitive information as reliable as human-level by learning with GPU and the large amount of data. (Sung, W. S., Baek, H., Sim, H., Kim, H. E., Hwangbo, H., Jang, J. Y. 2020)

2. Robotics and Automation:

Robotics technology has advanced to the point where robots can perform complex physical tasks with precision and adaptability, addressing the "difficult for computers" part of Moravec's Paradox.

The development of automation enabled by robotics and artificial intelligence brings the promise of higher levels of productivity and also better efficiency, security, and convenience described by (Company and Manyika, 2017,

3. Integration of Technologies:

The integration of various technologies such as IoT, cloud computing, and big data analytics into operations is a hallmark of new digital transformation, enabling real-time decision-making and predictive analytics.

4. Enhanced Customer Experience:

Digital transformation is increasingly focused on enhancing the customer experience through personalized services, which requires a deep understanding of human behavior and preferences, areas that were once difficult for machines to grasp.

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Leveraging digital capabilities and orientation by focusing on improved service delivery and customer integration can add value to the products and services they offer while increasing profitability over the long term. (Kindermann et al., 2020)

5. Operational Efficiency:

Digital transformation can help facilitate the creation, analysis, and utilization of large amounts of data, build an intelligent logistics supply chain by using modern technology, innovate the means of communication, and empower the overall operational efficiency of the entire industrial chain with industry chain integration and deep user involvement. (Du, H., Wang, J., Li, Q. 2021)

Breaking Moravec's Paradox:

As seen in the context of smart fashion retail, there is an effort to "break" Moravec's Paradox by creating platforms where humans and machines collaborate, leveraging machines' capabilities in areas that were once exclusively human domains. (Sung, W. S., Baek, H., Sim, H., Kim, H. E., Hwangbo, H., Jang, J. Y. 2020)

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New technologies can increasingly be applied in all types of operation

In summary, the "new" in digital transformation is characterized by the breaking of Moravec's Paradox through the development and application of advanced digital technologies that enable machines to perform tasks that were once considered uniquely human. This includes perceptual tasks like visual recognition and motor tasks like navigating complex environments.

The implications of overcoming Moravec's Paradox in the context of digital transformation are profound:

1. Collaborative Human-Machine Systems:

There is a growing trend towards creating systems where humans and machines work together synergistically. Machines can handle tasks that require precision, speed, and consistency, while humans can provide creativity, strategic thinking, and emotional intelligence.

2. Smart Operations:

In industries like fashion retail, as mentioned in the snippets, the goal is to improve operations by leveraging technology to reduce waste and enhance customer-centric approaches. This involves using visual-based technologies and other advanced algorithms to optimize distribution and inventory management. (Sung, W. S., Baek, H., Sim, H., Kim, H. E., Hwangbo, H., Jang, J. Y. 2020)

3. Sustainable Digital Transformation:

The push towards sustainability is also a key aspect of new digital transformation. Universities and other institutions are looking to integrate digital technologies in ways that promote sustainability, such as reducing e-waste, building energy efficiencies, and adopting cloud computing.

4. Challenges and Opportunities:

While new digital transformation offers numerous opportunities, it also presents challenges. For example, the banking industry has experienced both operational efficiencies and profitability paradoxes as a result of digital transformation. Banks are now required to carefully plan their digital transformation strategies to ensure sustainable development.

5. Macro Environmental Changes:

Rapid changes in the macro environment, including social trends and technological advancements, are driving the need for continuous adaptation and fine-tuning of digital transformation strategies.

6. Digital Entrepreneurship:

The delivery of digital education and other services through digital platforms is becoming an alternative mechanism for revenue generation and service provision, reflecting the broader trend of digital entrepreneurship.

In essence, the "new" in digital transformation is not just about adopting the latest technologies but also about rethinking and reshaping organizational strategies, processes, and cultures to harness the full potential of these technologies. It involves a shift towards more intelligent, sustainable, and human-centric approaches to business

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and operations, enabled by the convergence of digital capabilities that were once thought to be beyond the reach of machines.

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How do we view new digital transformation?

Gartner Hype Cycle

The Gartner Hype Cycle is a graphical representation of the maturity, adoption, and social application of specific technologies. It provides a conceptual framework that helps stakeholders understand the progression of a technology from its inception to mainstream adoption and the various stages of public perception and expectations along the way. Here's how the Gartner Hype Cycle can be used to view new digital transformation technologies:

1. Technology Trigger:

The cycle begins with the "Technology Trigger" phase, where a new technology is conceptualized or launched. It often involves a breakthrough, public demonstration, product launch, or other events that generate significant media attention and public interest.

2. Peak of Inflated Expectations:

As the technology gains exposure, it quickly reaches the "Peak of Inflated Expectations," characterized by a flurry of publicity and high expectations. During this phase, success stories—often accompanied by scores of failures—are highly publicized. Some businesses will adopt the technology early, driven by the fear of missing out or the desire to be seen as innovators.

3. Trough of Disillusionment:

As experiments and implementations fail to deliver, the technology slides into the "Trough of Disillusionment." Interest wanes as experiments and implementations fail to deliver on the overhyped expectations. Only technologies that continue to prove their worth to early adopters survive this stage.

4. Slope of Enlightenment:

Technologies that make it through the disillusionment phase enter the "Slope of Enlightenment." During this phase, the benefits of the technology become more widely understood and accepted, and second- and third-generation products appear from technology providers. More instances of how the technology can benefit the enterprise start to crystallize.

5. Plateau of Productivity:

Finally, the technology reaches the "Plateau of Productivity," where mainstream adoption starts to take off. The technology's broad market applicability and relevance are clearly paying off. If the technology has reached this stage, it has proven its real-world benefits and has become increasingly stable.

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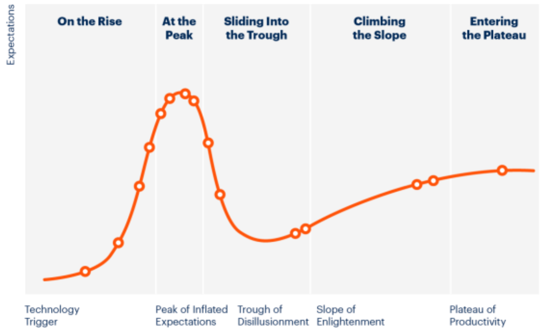

FIGURE 1. Gatner Hype Cycle https://www.gartner.com/en/marketing/research/hype-cycle

When viewing new digital transformation technologies through the lens of the Gartner Hype Cycle, stakeholders can better manage their expectations and make informed decisions about investing in, adopting, and implementing these technologies. It helps organizations to:

- Identify which technologies are overhyped and which have a real potential to impact their business.
- Understand the maturity of the technology and its current position in the cycle to make strategic decisions about when to adopt.
- Allocate resources effectively by recognizing the technologies that are likely to reach maturity and provide a competitive advantage.
- Avoid pitfalls associated with investing too early in immature technologies or too late in technologies that have already reached market saturation.
- Prepare for the challenges associated with each phase of the cycle, such as managing inflated expectations during the peak or pushing through the disillusionment phase by focusing on continuous improvement and finding the right use cases.

(O'Leary et al. 2008)

For businesses undergoing digital transformation, the Gartner Hype Cycle serves as a tool to assess the potential impact and readiness of new technologies. It encourages a more measured approach to technology adoption, emphasizing the importance of aligning business goals with the capabilities and maturity of the technology.

For example, a company might use the Hype Cycle to evaluate emerging technologies such as artificial intelligence (AI), blockchain, or the Internet of Things (IoT). By understanding where each technology is on the Hype Cycle, the company can plan its digital transformation initiatives more effectively, investing in technologies that are on the path to productivity and preparing for the challenges that may arise during the disillusionment phase.

In conclusion, the Gartner Hype Cycle provides a valuable perspective on new digital transformation technologies, helping organizations navigate the complex landscape of technological innovation. By using this framework, businesses can better time their investments, manage risks, and ultimately harness the transformative power of new digital technologies to drive growth and innovation.

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How can one understand the potential of digital transformation?

Understanding the potential of new process technology involves a thorough analysis of its capabilities, mechanisms, benefits, and associated risks. Answering the four key questions can provide a comprehensive understanding of the technology's impact on an operation:

1. What does the technology do that is different from other similar technologies?

Identify the unique selling points (USPs) or differentiators of the new technology compared to existing solutions. This could include improved efficiency, higher precision, lower costs, better scalability, or innovative features that address specific challenges. Understanding what sets the technology apart will help determine its potential to create a competitive advantage or solve existing problems.

2. How does it do it? That is, what particular characteristics of the technology are used to perform its function?

Examine the underlying mechanisms and technical specifications that enable the technology to deliver its unique capabilities. This could involve proprietary algorithms, advanced materials, novel engineering designs, or integration with other technologies. A deep dive into the "how" provides insights into the technology's sophistication, reliability, and potential for integration with current systems.

3. What benefits does using the technology give to the operation?

Assess the tangible and intangible benefits that the technology can bring to the operation. Benefits could include cost savings, time reductions, quality improvements, increased throughput, enhanced customer experience, or new capabilities that enable the development of new products or services. It's important to quantify these benefits where possible to justify the investment and to set benchmarks for measuring the technology's impact.

4. What constraints or risks does using the technology place on the operation?

Identify any limitations, challenges, or risks associated with implementing and using the technology. Constraints could be technical, such as compatibility with existing systems, or operational, such as the need for skilled personnel to manage the technology. Risks might include cybersecurity threats, potential for obsolescence, or high upfront costs. Understanding these factors is crucial for risk management and for developing contingency plans. (Kim et al. 2019).

Therefore, it is necessary to identify why a potential customer might look for an alternative to existing products. It may be because of the lower costs of products, superior performance, greater reliability, or simple fashion. (Bessant et al, 2013)

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Emerging technologies – understand their primary capabilities

Emerging technologies can be classified by their primary capabilities, which reflect the specific functions they are designed to perform. Understanding these capabilities is crucial for businesses looking to leverage these technologies for competitive advantage, especially in the context of Industry 4.0, which is characterized by the fusion of the digital and physical worlds.

Here's a breakdown of these categories:

1. Technologies that can think, or reason (Cognitive Technologies):

These technologies include artificial intelligence (AI), machine learning (ML), and data analytics. They are designed to mimic human cognitive functions such as learning, problem-solving, and decision-making. For example, reinforcement learning is an AI technique that improves the AI systems' ability to learn via trial and error without prior instructions from programmers, and could enable better learning abilities for robots, in particular robotic dexterity (MIT, 2017a, 2019b). Other examples include AI algorithms that can predict consumer behavior, ML models that optimize supply chain operations, and natural language processing (NLP) systems that understand and generate human language.

2. Technologies that can see, or sense (Sensory Technologies):

Sensor technology is not a new field, but there have been significant improvements in the last few years, allowing them to advance various technological fields (MIT, 2015, 2017e; PA consulting, 2017; WEF, 2015b).

Sensory technologies encompass a range of devices and systems that can detect and interpret the environment. Examples are cameras that monitor manufacturing processes for quality control, sensors that detect temperature changes in a storage facility, and LiDAR systems used in autonomous vehicles.

3. Technologies that can communicate, or connect (Connectivity Technologies):

These technologies facilitate communication between machines, systems, and humans. They include networking hardware, protocols, and platforms such as 5G, Wi-Fi, Bluetooth, and blockchain. They enable the exchange of data and coordination of activities across various components of an operation, such as real-time data sharing between different parts of a smart factory.

For example, 5 G, the new generation of mobile networks, allows data transfer over high speed and lower latency networks (Deloitte, 2019).

4. Technologies that can move physical objects (Robotic and Automation Technologies):

Advances in AI and sensor technology have enabled the development of more autonomous robots that can interact, adapt and respond to their environments (PA consulting, 2017; WEF, 2015a).

Robotic and automation technologies refer to machines and systems that can carry out physical tasks. This category includes industrial robots, drones, and automated guided vehicles (AGVs). They are used for tasks like assembly, packaging, material handling, and delivery.

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5. Technologies that can process materials (Material Processing Technologies):

Additive manufacturing refers to the automated process creating a 3D object from a computer model, typically building the object through depositing layer upon layer of some malleable material. (Borg, J., Zhang, W., Smith M. E., Holloway, C., 2021)

These technologies are used to transform raw materials into finished products. They include 3D printing, CNC machining, and chemical processing technologies. They are integral to manufacturing and production processes, allowing for the creation of complex and customized products.

6. Technologies with more than one primary capability:

Many emerging technologies have multifaceted capabilities that span across these categories. For example, a smart robot in a manufacturing plant may have the ability to think (AI for decision-making), see (sensors and computer vision for quality inspection), communicate (IoT connectivity to send and receive data), move physical objects (robotic arms for assembly), and process materials (precision tools for machining). These integrated technologies are often at the heart of Industry 4.0 solutions, as they combine various capabilities to create highly efficient, automated, and intelligent systems.

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Industry 4.0

Industry 4.0 is the current trend of automation and data exchange in manufacturing technologies, encompassing:

- Cyber-Physical Systems (CPS):

Cyber Physical Systems (CPS) that allow a self-organization and self-control of manufacturing and logistics systems (Rauch et al. 2016a; Rauch et al. 2016b). CPS are computers, sensors and actuators that are embedded in materials, equipment and machine parts and connected via the internet, the so-called "Internet of Things", allowing to merge the physical and digital world (Spath et al. 2013).

Woschank, Manuel & Dallasega, Patrick & Ramingwong, Sakgasem & Tippayawong, K.Y. & Chonsawat, Nilubon. (2019). Field study to identify requirements for smart logistics of European, US and Asian SMEs.
Rauch, E., Dallasega, P., Matt, D.T., The way from lean product development (LPD) to smart product development (SPD), *Procedia CIRP*, vol. 50, pp. 26-31, 2016a.
Spath, D., Ganschar, O., Gerlach, S., Hämmerle, T. K., Schlund, S., *Produktionsarbeit der Zukunft – Industrie 4.0*, Fraunhofer Verlag, Stuttgart, pp. 2-133, 2013.

- The Internet of Things (IoT):

The number of mobile devices has exceeded the number of the global population. (Simkó, M.; Mattsson, M.O., 2019). In this way, there is an increased interconnection between devices and machines, maintaining connections without direct human intervention. This network is known as the IoT to differentiate it from the traditional internet connecting people. (Kim et al. 2019).

- Cloud Computing:

The basic definition of cloud computing is described by (Armbrust et al., 2010) and is given as follows: "Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centres that provide those services." The services themselves have long been referred to as software as a service (SaaS). Some providers use infrastructure as a service (IaaS) and platform as a service (PaaS) to describe their products. (Kim et al. 2019).

- Cognitive Computing: This involves creating systems that simulate human thought processes in a computerized model, utilizing self-learning algorithms that use data mining, pattern recognition, and natural language processing to mimic the way the human brain works.
- Additive Manufacturing: Commonly known as 3D printing, this involves creating three-dimensional objects by adding material layer by layer, which allows for complex designs and rapid prototyping.

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- Advanced Robotics: These are robots capable of performing tasks in complex and dynamic environments, often with a high degree of autonomy, thanks to advances in AI and machine learning.
- Big Data and Analytics:

Big data technologies describe a new generation of technologies and architectures, designed to economically extract value from huge volumes of a wide variety of data, by enabling the high-velocity capture, discovery, and analysis (Labrinidis and Jagadish, 2012).

In the context of Industry 4.0, these technologies are not only transforming individual processes but are also leading to the creation of interconnected and smart factories where machines, systems, and humans communicate seamlessly to optimize production and create more value. The convergence of these technologies enables higher levels of automation, improved flexibility, and greater efficiency, leading to smarter, more responsive, and more efficient production processes.

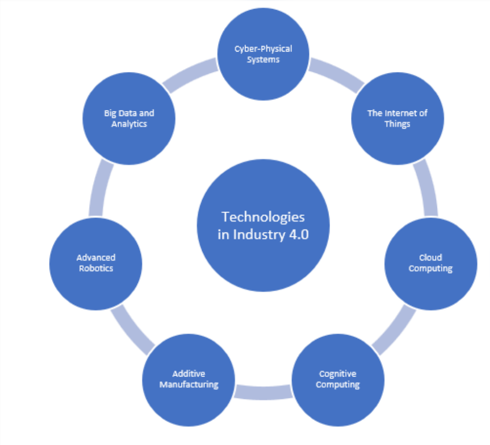

FIGURE 2. Technologies in Industry 4.0

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How can new digital transformation be evaluated?

Evaluating new digital transformation initiatives is critical to ensure they align with the organization's strategic objectives and deliver tangible benefits. Here are the key considerations for evaluating new digital transformation based on the questions provided:

1. Fit with Volume-Variety Characteristics:

Assess whether the digital transformation is suitable for the scale (volume) and diversity (variety) of the tasks it will address.
Therefore, digital transformation may have a more significant effect on improving the performance of manufacturing firms in regions with a higher degree of marketization. Wang H, Cao W, Wang F., 2022).
High-volume, low-variety tasks may benefit from automation and standardization, while low-volume, high-variety tasks might require more flexible and adaptable digital solutions. For example, a mass production line could be enhanced with robotics and automation, whereas a custom manufacturing operation might leverage 3D printing and AI to handle diverse customer specifications.

2. Improvement in Operation's Performance:

Through digital transformation, manufacturing enterprises can optimize different aspects of their logistics, production, and back-end services to significantly reduce their costs and achieve low-cost empowerment. (Wang H, Cao W, Wang F., 2022).

Determine the specific areas of operational performance that the digital transformation will enhance. This could include increased efficiency, reduced costs, improved quality, faster delivery times, or better customer service. It's important to set clear performance metrics and KPIs to measure the impact of the digital transformation. For instance, implementing an ERP system might streamline processes and reduce lead times, while deploying an AI-based analytics platform could improve decision-making and forecast accuracy.

3. Financial Return:

Conduct a financial analysis to evaluate the return on investment (ROI) of the digital transformation. This involves calculating the total cost of implementation (including hardware, software, training, and any disruptions to operations) and weighing it against the expected financial benefits (such as increased revenue, cost savings, or asset optimization). The analysis should consider both short-term and long-term financial impacts, and the digital transformation should meet the organization's criteria for an acceptable financial return.

In addition to these considerations, the following steps can help in the evaluation process:

- Benchmarking: Compare the proposed digital transformation with industry standards or competitors' practices to understand its relative value and potential for competitive advantage.
- Risk Assessment: Identify potential risks associated with the digital transformation, including technical, operational, and cybersecurity risks, and develop mitigation strategies.

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- Pilot Testing: Implement the digital transformation on a small scale or in a controlled environment to test its effectiveness and gather data before a full-scale rollout.
- Stakeholder Engagement: Involve key stakeholders, including employees, customers, and suppliers, in the evaluation process to gain insights into the potential impact and to ensure buy-in.
- Agility and Scalability: Ensure that the digital transformation is agile enough to adapt to changing business needs and scalable to accommodate growth. This means the technology should be able to handle increased demand without significant additional investment or reconfiguration.

4. User Adoption and Training:
   Evaluate the ease with which employees can adopt the new technology. Consider the training and support required to ensure a smooth transition. User adoption is critical for realizing the benefits of digital transformation.

5. Cultural Fit:
   Consider how well the digital transformation aligns with the organization's culture. The initiative should support and enhance the company's values and ways of working, rather than conflict with them.

7. Technology Compatibility and Integration:
   Assess how well the new technology integrates with existing systems. Seamless integration is essential to avoid silos and ensure that the organization can leverage its full technology stack effectively.

8. Data Utilization and Analytics:
   Determine how the digital transformation will improve data collection, analysis, and utilization. The ability to turn data into actionable insights is a key driver of value in digital transformation.

9. Customer Experience and Engagement:
   Evaluate the impact of digital transformation on the customer experience. The technology should enable better engagement, personalized services, and improved satisfaction.

10. Innovation Potential:
    Consider whether the digital transformation opens up new opportunities for innovation. This could include the development of new products, services, or business models that were not possible before.

11. Long-Term Strategic Fit:
    Ensure that the digital transformation is not just a short-term fix but is part of a long-term strategic plan that will provide sustainable competitive advantage and growth.

By addressing these additional points, organizations can conduct a comprehensive evaluation of new digital transformation initiatives, ensuring that they are not only technically sound but also strategically aligned and poised to deliver real business value.

(Wang H, Cao W, Wang F., 2022)

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How does the digital transformation improve the operation's performance?

Performance is the evaluation of an enterprise's operations, either from the results it has achieved or through the potential for future achievements (Tseng, S.-M. and Lee, P.-S., 2014). With the changes in market environments and the development of digital technology, enterprises urgently need to develop the capability to adapt to profound changes in strategy and business processes. (Yu J, Wang J, Moon T., 2022)

Digital transformation can significantly improve an operation's performance by leveraging modern technologies to optimize processes, enhance decision-making, and create new business models.

Here's how to evaluate the impact of digital transformation based on the listed criteria:

1. Capability Enhancement:

Digital transformation capability refers to the enterprise's ability to use advanced platforms such as information, communication, and control mechanisms. (Yu J, Wang J, Moon T., 2022)

Digital transformation often introduces capabilities such as advanced data analytics, AI-driven insights, or automation of routine tasks. These capabilities can enable operations to do things that were previously impossible, such as predictive maintenance or personalized customer experiences.

2. Quality of Execution:

Technologies like machine learning and process automation can reduce human error and increase precision in tasks. This leads to higher quality outcomes, fewer mistakes, and a more consistent product or service.

3. Speed of Operation:

Digital tools can streamline workflows and automate processes, leading to faster completion of tasks. For example, cloud computing enables rapid access to resources and services, while AI can quickly analyze large datasets.

4. Reliability:

Digital systems can offer improved uptime and less variability in performance. Redundant systems, cloud infrastructure, and real-time monitoring contribute to a more reliable operation.

5. Flexibility and Responsiveness:

In market dynamics such as economic globalization and diversification of consumer demand, a dynamic capability refers to the organization's flexible capability to properly allocate internal and external resources, quickly make marketable products, effectively grasp changing business opportunities, and continuously maintain a competitive advantage. (Yu J, Wang J, Moon T., 2022)

Digital solutions can be designed to be modular and scalable, allowing for easy adaptation to changing demands. For instance, software-defined networking enables quick reconfiguration of network resources.

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6. Task Range:

Digital technologies can often handle a wide array of tasks, from data processing to customer relationship management. Integrated platforms can cover various aspects of an operation, reducing the need for multiple disparate systems.

7. Sustainability:

Digital transformation can lead to more sustainable operations by optimizing resource use and reducing waste.

More and more enterprises are beginning to use digital technology to promote transformation and upgrading, developing sustainable digital transformation capabilities by reshaping the value chain, and achieving production and developmental benefits. (Yu J, Wang J, Moon T., 2022)

For example, IoT devices can monitor energy consumption and help in implementing energy-saving measures.

8. Location Versatility:

Many digital technologies are not bound to a specific location and can be accessed remotely. Cloud services and mobile technologies enable tasks to be performed from virtually anywhere.

9. Safety:

Digital technologies can enhance safety by providing better monitoring tools, predictive analytics for risk assessment, and automation that removes humans from dangerous environments.

For example, automotive companies use sensors to detect blind spots to avoid accidents and enhance the safety features of their products (Svahn, F.; Mathiassen, L.; Lindgren, R., 2017).

10. Connectivity:

The interconnected nature of digital technologies allows for seamless communication between systems, devices, and stakeholders. This connectivity enables better collaboration and data-driven decision-making.

11. Security:

While digital systems can be vulnerable to cyber threats, they also come with advanced security measures.

Most enterprises in the era of the 4th Industrial Revolution need to develop and implement digital transformation capabilities. In order to eliminate uncertainty and obtain sustainable competitiveness in a highly competitive environment, enterprises try to sense environmental changes and establish digital strategies, organize internal and external resources, and restructure them in connection with business processes within the organization. (Yu J, Wang J, Moon T., 2022).

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How is digital transformation developed and implemented?

Developing and implementing digital transformation involves a strategic approach that encompasses understanding current capabilities, envisioning future needs, and integrating new technologies in a way that aligns with the organization's goals. Here's how the process typically unfolds:

1. Technology Planning and Roadmapping:

Roadmapping is a structured visual mapping method to support strategy, long-term planning, innovation, and foresight activities (Kerr and Phaal 2022).

Roadmapping is an established and proven approach used globally for supporting technology and strategic planning, thus facilitating innovation. Sustaining the implementation of organizational roadmapping can prove challenging due to its inherently flexible and adaptable nature. (Hirose, Y. et al. 2022).

Assessment: Begin with a thorough assessment of existing technologies, processes, and business models to identify areas for improvement or potential disruption.
Vision: Define a clear vision for the future state of the organization, considering industry trends and potential technological advancements.
Roadmap Development: Create a technology roadmap that outlines the path from the current state to the desired future state. This includes identifying key technologies, setting milestones, and establishing timelines.
Alignment: Ensure that the technology roadmap aligns with the overall business strategy and objectives, and that it has the flexibility to adapt to changes in technology and market conditions.

2. Customer Acceptability:

Roadmapping offers customers an opportunity to propose new perspectives and companies to realize superior and sustainable solutions. (Hirose, Y. et al. 2022).

User-Centered Design: Design digital transformation initiatives with a focus on user experience (UX) to ensure that new technologies meet customer needs and preferences.
Feedback Mechanisms: Implement mechanisms to gather customer feedback throughout the development and implementation process.
Market Research: Conduct market research to understand customer expectations and acceptance levels for new technologies.
Pilot Programs: Run pilot programs or beta tests with a subset of customers to validate concepts and refine the technology before full-scale deployment.

3. Anticipating Implementation Problems:

Risk Analysis: Perform a risk analysis to anticipate potential implementation challenges, such as technical issues, resistance to change, or regulatory hurdles.
Change Management: Develop a change management plan that includes communication strategies, training programs, and support structures to facilitate the transition for employees and stakeholders.
Contingency Planning: Create contingency plans for critical risks to ensure business continuity in case of unforeseen problems.

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Iterative Approach: Adopt an iterative approach to implementation, allowing for adjustments based on feedback and changing conditions. This can involve agile methodologies and continuous improvement practices.

4. Implementation:

Infrastructure Preparation: Upgrade or adapt existing infrastructure to support new technologies, ensuring compatibility and scalability.
Integration: Integrate new technologies with existing systems, ensuring seamless data flow and functionality.
Training and Support: Provide comprehensive training for employees and ongoing support to ensure they are equipped to use the new technologies effectively.
Monitoring and Evaluation: Establish metrics and KPIs to monitor the performance of the new technologies and assess their impact on operations. Regularly evaluate progress against the technology roadmap and make necessary adjustments.

5. Scaling and Optimization:

Scaling Up: Once the technology has been tested and refined, begin scaling up to full operational deployment. This may involve a phased approach to manage risks and ensure smooth integration.
Continuous Optimization: Use data collected from the new systems to continuously optimize processes and technology performance. This can involve machine learning algorithms that improve over time or regular updates to software and systems.

Roadmapping is a "living" vehicle that supports technology and strategic planning, and thus evolves gradually and adapts to the organizational context. (Hirose, Y. et al. 2022)

6. Stakeholder Engagement:

Stakeholder engagement within companies comprises getting a critical mass of internal people to understand the impacts and benefits of roadmapping (Gerdsri, Vatananan, and Dansamasatid 2009).

Internal Communication: Keep all internal stakeholders informed about the digital transformation process, its benefits, and its progress. This helps to build support and manage expectations.
External Communication: Communicate with external stakeholders, such as customers, suppliers, and partners, about changes that may affect them and how the transformation will bring value to them.

7. Legal and Regulatory Compliance:

Compliance Checks: Ensure that all new technologies comply with relevant laws, regulations, and industry standards. This includes data protection laws, accessibility standards, and any sector-specific regulations.
Data Governance: Implement robust data governance practices to manage the collection, storage, and use of data in compliance with privacy laws and ethical standards.

8. Security and Privacy:

Cybersecurity Measures: Implement advanced cybersecurity measures to protect new digital systems from threats. This includes encryption, access controls, and regular security audits.

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Privacy Protections: Ensure that customer and employee data is handled in accordance with privacy laws and best practices, including GDPR, CCPA, or other relevant frameworks.

Roadmapping is a "living" vehicle that supports technology and strategic planning, and thus evolves gradually and adapts to the organizational context.

By following these steps, organizations can develop and implement digital transformation in a structured and strategic manner, maximizing the chances of success and minimizing the risks associated with adopting new technologies.

(Hirose, Y. et al. 2022)

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