THE IMPACT OF INFORMATION AND COMMUNICATION TECHNOLOGY ON CIVIL ENGINEERING IN THE 21ST CENTURY

Prof. T. Kalaikumaran
Department of Artificial Intelligence and Data Science
VSB College of Engineering Technical Campus
Coimbatore, Tamil Nadu
India

AND

Prince Uko EBENEZER
Corporate Institute of Research and Computer Science
140 Ikot Ekpene Road
Uyo, Akwa Ibom State

ABSTRACT

This paper was to assess the impact of information and communication technology on civil engineering in the 21st century. Information and Communication Technology is playing a vital role in virtually almost every field of human operation such as education sector, medical field, banking sector, agricultural sector, field of engineering and more. Information and Communication Technology has substantially eased operations in several fields and has helped to save resources in the likes of labor, cost and time. It has also helped to drastically increase the speed at which work is done. It also reviewed the impact of information and communication technology in civil engineering practice and examines operations such as the construction industry, road transportation industry, engineering education, structural engineering, energy efficient buildings, building preservation and engineering design. Information and Communication Technology is seen to be very relevant for sustainability in civil engineering practices across literature. It was on this basis that the paper concluded that researchers are developing visual simulation of construction process each day which is regarded as the significant step forward for the perfection in design. It Challenges the existing methods of evaluation that are often more laborious and time consuming. The success stories of utilizing ICTs in developed countries have drawn the attention of researchers in developing countries like Nepal regarding the beneficial effects of using ICTs into construction processes. The uses of technology in construction are complex and expensive solutions. Although it's initial cost is more significant the use of ICT is found to have long term benefits in the construction process. One of the recommendations was that in order to ensure that civil engineers become ICT literate engineers, higher learning coordinators, particularly for institutions, should provide civil engineering courses that play major roles in imposing the ICT value to civil engineering.

KEYWORDS: Information and Communication Technology, Civil Engineering and 21st Century

Introduction

The use of information and communication technology has been recognized to have a significant impact on the way of life in developing nations. Information and communication technology is widely employed in the field of civil engineering to help engineers manage their workload, save money and time, get the finest designs, and satisfy client expectations. Civil engineering is concerned with providing for the needs of modern society. So, information and communication technology is concerned

with improvements in a variety of human problem-solving endeavors through the design, development, and use of technologically based systems and processes that enhance the efficiency and effectiveness of information and associated knowledge in a variety of strategic, tactical, and operational situations (Ramli & Yunus, 2005). Civil engineers possess both general and some specialized ICT-related knowledge to be able to specify and participate in the development of new ICT tools and to be proactive in the process of changing work routines and company and project organization. Information and communication technologies (ICT) have become conventional entities in all aspects of life, including civil engineering. Across the past twenty years, the use of ICT has fundamentally changed the practices and procedures of nearly all forms of endeavor within civil engineering, business, and governance. According to Oluwafemi, Ede, Ofuyatan, Oyebisi, and Bankole (2021), the application of information and communication technology is very vital to achieve cost reduction, operational time reduction, safety, and more in civil engineering practices. Hence, ICT remains relevant to the field of civil engineering and engineering at large.

Information and communication Technology is playing a vital role in virtually every field of human operation, such as the education sector, medical field, banking sector, agricultural sector, field of engineering, and more. Information and communication technology has substantially eased operations in several fields and helped to save resources like labor, cost, and time. It has also helped drastically increase the speed at which work is done. Information technology has brought an industrial revolution to the construction process throughout the world (Ramli and Mesir, 2014). It has led to general improvements in the performance of construction processes in terms of expenditure, time, quality, and client satisfaction. In modern times, ICT can be implemented into different phases and methods of the construction project. Here, construction processes represent the whole life cycle of construction, including pre-design, design, development, operation, and maintenance. Use of ICT improves coordination, procedures, and collaboration between the customer, contractor, and engineer. Information technology has brought an industrial revolution to the construction process throughout the world (Ahmad, 2014). ICT in civil engineering has witnessed a continuous increase over the years, being that it has continued to gain acceptance in operations across this industry. With the introduction of ICT in civil engineering, it is now possible to model projects in a virtual environment prior to their physical implementation.

Statement of Problem

The adoption of ICT is not as straightforward as it might be, but there are several recurring difficulties, including inadequate awareness of IT and its advantages, price rises for IT equipment as a result of government regulation, and new technology that necessitates learning new skill sets. For a construction project to be completed on time, cheaply, and effectively, cooperation is required. A crucial component of collaborative working is ICT efficiency throughout the project life cycle. A project involves plenty of individuals. Organization and management of this communication process become more challenging the larger the population. All project information is gathered into one database by a sophisticated project information management and sharing system, which then distributes it to the appropriate participant to increase collaboration.

Concept of Information and Communication Technology

Information and communications technology refers to the technology that supports activities involving information. Such activities include gathering, processing, storing, and presenting data. Increasingly, these activities also involve collaboration and communication. Information and communications technology are the infrastructure and components that enable modern computing (Pratt, 2022). Information and communications technology (ICT) is an extensional term for information technology (IT) that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals) and computers, as well as necessary enterprise software, middleware,

storage, and audio-visual that enables users to access, store, transmit, understand, and manipulate information. According to IGI Global (2020), ICT refers to technologies that provide access to information through telecommunications and focuses on communication technologies. This includes the Internet, wireless networks, mobile phones, and other means of communication. ICT is the technology that supports activities involving information. Such activities include gathering, processing, storing, and presenting data. Increasingly, these activities also involve collaboration and communication. ICT refers to a technology that is used to handle communications processes such as telecommunications, broadcast media, intelligent building management systems, audio-visual processing and transmission systems, and network-based control and monitoring functions (Techopedia, 2020). ICT is defined as a diverse set of technological tools and resources used to transmit, store, create, share, or exchange information. These technological tools and resources include computers, the Internet (websites, blogs, and emails), live broadcasting technologies (radio, television, and webcasting), recorded broadcasting technologies (podcasting, audio and video players, and storage devices), and telephony (fixed or mobile, satellite, video-conferencing, etc.).

Information and Communication Technology (ICT) first appeared in the mid-1980s and was defined as "all kinds of electronic systems used for broadcasting telecommunications and mediating communications," with examples including personal computers, video games, cell phones, the internet, electronic payment systems, computer software, etc. ICT is made up of computer and communication technology. Computer technology is the tool for storing and processing information in digital form, while communication technology helps us transfer and disseminate digital information. Information and communication technology (ICT) may be defined as the convergence of electronics, computing, and telecommunications. It has unleashed a tidal wave of technological innovation in the collecting, storing, processing, transmission, and presentation of information that has not only transformed the information technology sector itself into a highly dynamic and expanding field of work that not only opened up new markets and brought in new investment, income, and jobs but also gave other industries faster and more effective ways to adapt to changes in demand patterns and shifts in global comparative advantage through more effective manufacturing techniques and new and improved products and services (Sage, 2012). Today, almost every industry is included in the concept of information and communication technology (ICT), which has grown significantly. Every industry that conducts everyday business relies on information and communication technology professionals, including manufacturers, merchants, banks, and publishers, as well as research organizations, medical facilities, law enforcement agencies, public utilities, and libraries. ICT is consistently defined as the following by dictionaries: running a computer network; making original web pages; making digital videos; consulting on computer system design; selling goods online; creating 3-D artwork; running a company's database; writing software; offering technical support; managing projects and budgets; and writing technical documentation. Information and communication technologies are combined to produce ICT.

Concept of Civil Engineering

Civil engineering is a professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, airports, sewage systems, pipelines, structural components of buildings, and railways. Civil engineering is traditionally broken into a number of sub-disciplines. It is considered the second-oldest engineering discipline after military engineering, and it is defined to distinguish non-military engineering from military engineering. Civil engineering can take place in the public sector, from municipal public works departments through federal government agencies, and in the private sector, from locally based firms to global Fortune 500 companies (Wikipedia, 2022). Civil engineering is the application of physical and scientific principles for solving the problems of society, and its history is intricately linked to advances in the understanding of physics and mathematics throughout history. Because civil engineering is a broad profession that includes several specialized sub-disciplines, its

history is linked to knowledge of structures, materials science, geography, geology, soils, hydrology, environmental science, mechanics, project management, and other fields (Baveystock, 2013). Throughout ancient and medieval history, most architectural design and construction was carried out by artisans, such as stonemasons and carpenters, who rose to the role of master builders. Knowledge was retained in guilds and rarely supplanted by advances. Structures, roads, and infrastructure that existed were repetitive, and increases in scale were incremental. One of the earliest examples of a scientific approach to physical and mathematical problems applicable to civil engineering is the work of Archimedes in the 3rd century BC, including the Archimedes Principle, which underpins our understanding of buoyancy, and practical solutions such as Archimedes' screw. Brahmagupta, an Indian mathematician, used arithmetic in the 7th century AD, based on Hindu-Arabic numerals, for excavation (volume) computations.

Impact of Information and Communication Technology on Civil Engineering

Using Drones for Surveying Land: Civil and geotechnical engineers have found a new use for drones by using them to survey land. They have found that unmanned aerial vehicles provide a quick and safe way of measuring out large tracts of land for surveying purposes without risking human life by sending people into harm's way or into treacherous terrain. In rock blasting applications, engineers are able to conduct surveying from a distance to avoid exposure to blasting areas. These unmanned flying machines can map the earth's surface with incredible accuracy, so they're being used more and more often in surveying. Drone usage is most prevalent among construction managers, who are able to quickly assess their worksite while avoiding hazards such as heavy machinery or scaffolding that pose safety risks not only for themselves but also for others around them (Damkor, Irinyang, and Haruna, 2015). In addition, in an effort to find new ways of dredging, civil engineers may have found a solution that could help make the process less labor-intensive. In many industries (such as mining), dredging is often done by hand and can be difficult work for those who are involved in this kind of manual labor on site. However, with the use of drones, there has been significant progress in dredging while also reducing costs significantly when compared to traditional methods, which require more manpower than necessary just to get the job done.

Designing Structures with CAD Software: The tools of today's civil engineers are far more advanced than the tape measures and graph paper they used in years past. The work has also become much less tedious with time, thanks to computer-aided design software. With state-of-the-art CAD software, civil engineers can design structures that are more efficient and cost-effective. Civil engineers can now create and manufacture designs for machine parts, tools, buildings, and other structures with more accuracy thanks to computer-assisted drafting (CAD) programs like Autodesk Inventor Fusion 360. These highly sophisticated tools allow users to plan out their creations and prototypes digitally in a 3D space that gives them complete control over every detail from start to finish, including making changes on the fly as they please without having any fear of destroying materials or wasting time by needing physical prototypes first (Sebastian and Jochen, 2014).

Enabling Remote Sensing Via Cloud Technologies: Remote sensing is one advance that allows for remote monitoring on-site with minimal interference from physical presence. Civil engineers can now monitor construction progress from the comfort of their homes thanks to remote sensing technology. For example, they might use a thermal camera to detect hot spots on underground pipes or send an unmanned aircraft system into the airspace over the site for aerial views and photographs. Civil engineers can use remote sensing to monitor the progress of a construction project without being physically present for any part of it. They'll be able to see what's happening in real-time through live video feeds or take pictures and videos with drones that fly around, taking photos from all angles. But let's not forget, remote sensing would not be possible if it weren't for today's mobile and cloud technology. Cloud technology enables the possibility to access, modify, and manage data stored on

remote servers. For improved collaboration and information sharing, both mobile and cloud technologies enable real-time data sharing to all participants in any building construction process.

Connecting Devices in Cities- Internet of Things (IoT)-Enabled Sensors: In today's industries (oil and gas, manufacturing, food, dairy, etc.), civil engineers are not only responsible for designing and building infrastructure that sustains us but also creating automated systems to help make our lives easier (Mehdi, 2012). This is why the term "Industry 4.0" has been coined: it focuses on improving production efficiency by allowing automated machines to communicate with each other without human intervention using sensor networks connected via the Internet of Things (IoT). The internet of things is one step closer to reality. As more smart devices become interconnected, this opens up a whole new level of innovation that will change everything about how we live and work in our city. Smart factories (aka "factories of the future") can reduce operating costs while generating quality products at a faster rate than traditional methods used before Industry 4.0 was introduced because they use sensors embedded into machinery that collect real-time data through machine learning algorithms, so there's no need for humans to work long hours or shifts over. But let us return to IoTs. It's a fact: civil engineers have been hard at work connecting new technologies to our cities by way of connected smart objects, aptly referred to as the "IoT." With the use of PLCs, HMIs, and SCADA, these IoT-enabled sensors can tell engineers things like how much water a pipe is carrying or what the traffic volume looks like on any given day, for example. Building sensors into these structures allows civil engineers to monitor them easier than ever before from anywhere on earth using modern communication technologies such as cellular phones and satellites. One application that can really make a difference for natural disaster relief efforts and disaster restoration, such as earthquakes or floods, would be IoT-enabled sensors with predictive analytics features. Using IoT methods can help save billions of dollars per year lost due to damages caused by natural disasters because it would allow disaster relief crews faster access.

The use of Building Information Modeling (BIM): Professional civil engineers are in high demand, and the business of building information modeling (BIM) is booming. BMI technology has been around for at least 15 years now, but it's only recently become a household name among civil engineering professionals as they've had to deal with increasingly complex projects that have required more data visualization technologies than previously existed. Interestingly enough, many people who use this type of software don't even realize it was created by civil engineers. Civil and structural engineers are using Building Information Modeling (BIM) and data visualization technologies to create more efficient and sustainable buildings. This is an advanced system that helps keep track of all parts involved in constructing buildings through various means, like cameras installed throughout the site and data gathered from sensors embedded within materials used during each stage. With Building Information Modeling (BIM) technology dashboards, civil engineers can monitor everything about their project at all times throughout every step of its development process. This technology also allows experts to review project results in real-time, enabling better collaboration. BMI dashboards help building owners, investors, developers, contractors, and regulators stay informed about every detail related to their project, from site analysis data like soil types or geological conditions, for example, right down to individual components that go into constructing the actual structure itself, such as steel rebar size requirements or required spacing between posts on an exterior beam wall system. BMI is the perfect support for clash detection and problem-solving during design, which improves planning and increases efficiency.

The Use of Big Data: Historical big data can pick out patterns and probabilities of risks, increasing safety. Big data from weather, traffic, and the environment can determine the optimal phasing of activities to improve efficiency. "Big data" is a term used to describe extremely large data sets that can be used to uncover hidden trends, patterns in behavior, and unknown correlations. Civil engineering has been around for a long time, but now they have access to more powerful tools than ever before—in this case, "big data." Civil engineers are always on call during major storms or earthquakes; however,

thanks to all of the information available, today's civil engineer is much better equipped to assess their impact. Civil engineers use big data to forecast the behavior of natural disasters and assess their environmental impacts. Big data is important for construction technology because it can help uncover hidden trends and patterns in behavior that might not be seen with a small sample size. Bigger samples allow us to make more informed decisions about the way we use our resources, which leads to an increase in productivity within any industry (Aimie, Graham, and Christine, 2015).

The Use and Development of Water Conservation Technology: Civil engineering has developed different and innovative water conservation technologies, from residential and commercial solutions to systems used nationwide. The average American residence consumes more than 300 gallons of water per day, which translates to nearly 110,000 gallons per year (most of it from daily hot showers). When you factor in all of your multi-tenant buildings, that's a lot of water. Thankfully, engineers and designers have developed many viable tactics and water conservation methods for reducing water consumption and correcting water meter inaccuracies in ways that will have a real impact on your bottom line. Some examples include: shower flow controllers, leak detection systems, toilet leak prevention devices, and water flow management devices. Innovation often comes as small ideas like these form into larger concepts with potentially huge impacts. For example, the elimination of excess is so important in our current drought conditions that the use of these new inventions could be a solution to this problem. Similarly, civil engineers have been working tirelessly for years on developing sustainable and efficient technologies relating to water sustainability, but their work may finally pay off as we face one of the worst droughts in recent memory nationwide, with California being most severely impacted by it all due largely to its reliance on agriculture, which requires copious amounts of irrigation. This means there's more need than ever before for people to look at ways they can conserve water without cutting into production or lifestyle quality whatsoever if possible, or to wait patiently until things get better again if that's not possible (Yuan and John, 2018).

Develop 3D Printing Solutions: Civil engineering and 3D printing are two of the most important innovations in construction technology. These techniques have both changed how buildings, bridges, roads, dams, etc., can be constructed with an efficiency never before possible. A well-known example is that today's modern skyscraper could not even exist without it! 3D printing enables civil engineers to prefabricate ready-to-use materials, either offsite or directly on site. Large-scale 3D printing is used today to create houses, bridges, and other structures that would have been difficult or impossible before. Civil engineering has come a long way since the days of clay bricks (Sebastian and Jochen, 2014).

The Use of Digital Marketing: The fields of civil engineering and digital marketing are dynamic and evolving. The two fields overlap in an interesting way because both deal with the concept that information has value on its own merits. Civil engineers use math to determine how much material it would take to build bridges or design structures, while marketers analyze data about customers' buying habits, such as their age range and income level, to help companies find ways to attract new clients through targeted advertising campaigns. Today, civil engineers have been able to make a successful venture into inbound marketing and SEO (search engine optimization). The economic downturn has had an adverse effect on the civil engineering industry, causing many companies to lower their prices in order to compete for new contracts and jobs (Ede, Oshokoya, Oluwafemi, Oyebisi, and Olofinnade, 2018). In response, some of these firms have expanded into other areas such as website development, SEO optimization, or strategic inbound marketing campaigns that they may not have traditionally been involved with but that can still provide additional revenue streams.

Conclusion

Researchers are developing visual simulations of the construction process each day, which are regarded as a significant step forward for the perfection of design. It challenges the existing methods of

evaluation that are often more laborious and time-consuming. The success stories of utilizing ICTs in developed countries have drawn the attention of researchers in developing countries like Nepal regarding the beneficial effects of using ICTs in construction processes. The applications of technology in construction necessitate complex and costly solutions. Although its initial cost is more significant, the use of ICT is found to have long-term benefits in the construction process. Nepalese contractors can save a considerable amount of Nepalese currency from foreign contractors by using new technology efficiently. As a result, developing countries like ours must recognize the need for new information and communication technologies in civil engineering prospects in order to break the technical crisis.

Recommendations

1. Civil engineers should have both general and some specialized ICT-related knowledge to be able to specify and participate in the development of new ICT tools and to be proactive in the process of changing work routines and company and project organization.
2. Higher learning coordinators, particularly for institutions, should provide civil engineering courses that play major roles in imposing the ICT value on civil engineering in order to ensure that civil engineers become ICT literate engineers.
3. Regular maintenance of the constructed structures can be done using ICT.

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