

# Comparative Analysis of Digital Technology in Architectural, Engineering Construction Industries Across Six Continents of the World: A Global Perspective

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**Abstract.** This paper investigates integrating and comparing digital technology in the architectural, engineering, and construction (AEC) industry on the world's six continents, concentrating on the adoption of designs, points of interest, and suggestions for AEC instruction. The study draws insights from current research and industry reports to underline the five most recent popular digital technologies—building Information Modeling (BIM), 3D Printing, the Internet of Things (IoT), Digital twins, and GIS—and their significance and the importance of aligning construction education with industry innovations. The subject utilizes an online survey, exhaustive online information search (using search engines), and choices of journals for the investigation. To begin with, the five biggest economies nations of each continent, but Antarctica was partially utilized for comparison in this subjective research to complete the seven continents of the world. The result appears that North America (US and Canada) and Europe (UK, France, and Germany) are the driving pioneers and early adopters of digital technology in architecture, engineering, and construction. Asia (China, Seoul) The AEC market is adopting this digital technology spontaneously. Oceania (except Australia) is behind Asia in the adoption rate; South America and Africa are the late adopters of this digital technology in the industry.

**Keywords:** Civil Engineering; Continent; AEC; Digital Technology; Adoption.

## INTRODUCTION

The seven continents are Africa, Antarctica, Australia, Asia, Europe, South America, and North America. The architecture, engineering, and construction (AEC) sector is undergoing a digital revolution, changing from old processes or traditional ways to new technological solutions. This movement is motivated by the demand for better and faster production timelines and intelligent, efficient, effective, and competitive engineering works.

Advanced innovation in development is changing the industry, making forms more productive, diminishing costs, and making strides in security. A few nations are leading the way in choosing and improving computerized advances in AEC.

The populace is expanding worldwide, and the need for gracious Building works to meet up is suddenly rising from tall commercial buildings to thruway development, auxiliary plans, natural engineering (dam, water quality, and treatment), etc. In other words, the development segment has long been related to conventional hones and a moderate selection rate of inventive advances. In any case, a meaningful move towards digitalization has been seen a long time later, with firms grasping imaginative apparatuses and forms to improve ability, efficiency, and supportability [1].

The civil engineering industry, known for its traditional methods, has been identified as a slow sector in adopting technology, with little or no investment in research and development compared to other industries [2, 3]. Various technologies have been implemented to address the challenges faced by the AEC industry, and modern innovations have been introduced to enhance safety and productivity in the AEC sector [4].

Civil engineering works have long been essential to developing infrastructure, urbanization, and economic expansion in AEC. The technology and process digitization associated with the so-called Fourth Industrial Revolution has significantly changed civil engineering practices worldwide. A new, more digital work strategy has compelled the civil engineering industry to adopt it, and with proper application, it might create lucrative opportunities for AEC. Digital technology is being adopted and used in industrial systems and everyday human activities at a rate that has increased recently. Civil engineering

is still lagging behind other industries in adopting digital technology while manufacturing, banking, healthcare, and medicine have all embraced multifaceted methods for this process. The AEC sector faces various obstacles due to its rigidity in adopting novel techniques and technological advancements. Many civil engineering projects, including infrastructure, commercial, industrial, and residential, have been built throughout some parts of the world's continent. Support for national development goals and initiating large-scale projects like public-private partnerships, housing programs, and transportation infrastructure upgrades have stimulated investment in the civil engineering industry. The report investigates the use of digital technologies, identifies the developing trends, and assesses the hurdles to their complete application.

Some countries have embraced digital technologies in architecture and engineering, and civil engineering is the leading discipline in AEC. In the UK, BIM is mandatory for every public project. The Government of Brazil established the use of BIM through Decree No 10,306 of April 2, 2020.

Of BIM in the direct or indirect execution of engineering works and services conducted by agencies of the federal public administration, Australia's case is slightly different. Thanks to its relationship with the United Kingdom and New Zealand, they have been making massive progress in implementation [5].

The African AEC Industry often relies on traditional AEC methods and techniques, which usually involve manual, labour-intensive processes. Modern techniques must improve productivity and quality, hindering the industry's progress [6].

The research team conducted an exhaustive literature search using data sources from Statista, journals, Google search, Britannica, and others, resulting in the download of twenty publications. The research team removed eight publications not connected to the article topic and identified six others as duplicates during the comprehensive screening procedure. The remaining papers and online articles gave valuable insights into the advantages, trends, and issues connected with digital technology adoption in the architectural, engineering, and construction professions.

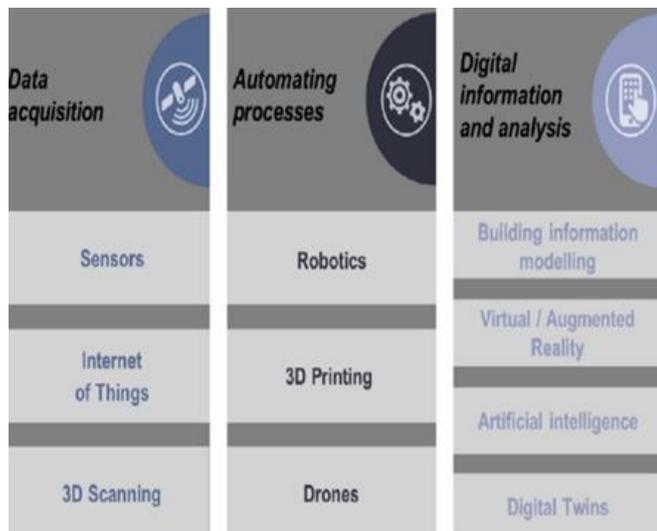


Figure 1 – The digital technologies section



Figure 3 – The map of the continent

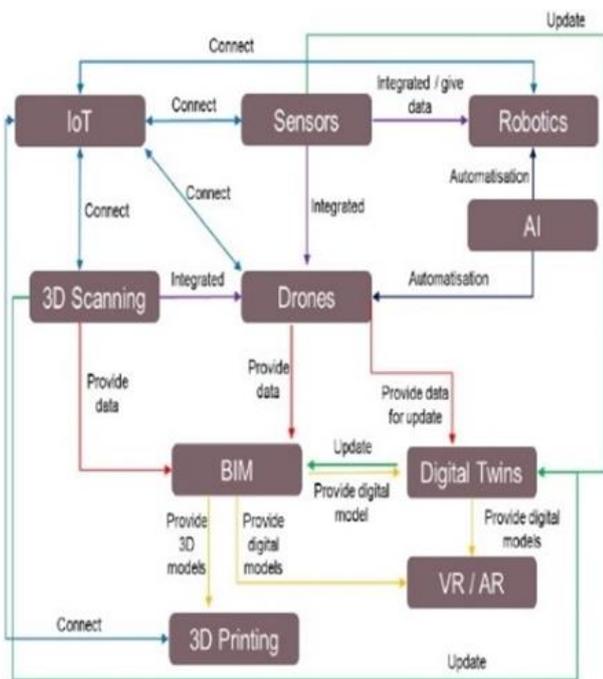


Figure 2 – Digital technologies interconnectivity

**Continents Review**

The list orders America, Antarctica, Europe, and Australia by size. (Europe and Asia are sometimes considered a single continent, Eurasia.)

*Africa.* Africa is the world's moment biggest and second-most crowded landmass after Asia. At approximately 30.3 million km<sup>2</sup> (11.7 million sq mi), counting adjoining islands, it covers 20% of Earth's arrival region, and 6% of it adds up to the surface range.

With 1.4 billion individuals as of 2021, it accounts for almost 18% of the world's population. Africa's populace is the most youthful among all the continents; the middle age in 2012 was 19.7, while around the world, the middle age was 30.4. Despite a broad run of joint assets, Africa is the slightest affluent landmass per capita and second-least well off by adding up to riches ahead of Oceania. Researchers have credited this to diverse components: topography, climate, debasement, colonialism, the Cold War, and neocolonialism. Despite this moo concentration of riches, later financial extension and the expansive and youthful populace make Africa a vital financial showcase worldwide [7].

*Oceania.* Oceania is a topographical locale that includes Australasia, Melanesia, Micronesia, and Polynesia. Oceania is considered a landmass outside of the English-speaking world. In contrast, Australia is respected as an island or a mainland landmass containing the interior of the enormous landmass of Oceania. Traversing the Eastern and Western Sides of the equator, at the middle of the water half of the globe, Oceania is assessed to have an arrival zone of around nine million square kilometres (3,500,000 sq mi) and a populace of around 44.4 million as of 2022. When compared to the continent (which it is regularly compared to, not counting Australia), Oceania is the littlest in the zone and the second-least populated after Antarctica [8].

*Asia.* Asia is the world's most enormous landmass regarding arrival range and populace. It covers a zone of more than 44 million square kilometres, around 30% of Earth's add up to arrive region and 8% of Earth's add up to surface zone. The landmass, which has long been domestic to the lion's share of the human populace, was the

location of numerous beginning civilizations. Its 4.7 billion individuals are 60% of the world's population [8, 9].

Asia is the biggest continent in the world. It can be divided into five prominent physical locales: mountain frameworks, levels, fields, steppes, deserts, freshwater, and saltwater environments.

*Antarctica.* Antarctica is Earth's southernmost and least-populated landmass. Arranged entirely south of the Antarctic Circle and encompassed by the Southern Sea (also known as the Antarctic Sea), it contains the geographic South Shaft. Antarctica is the fifth-largest landmass, being around 40% bigger than Europe, and has a zone of 14,200,000 km<sup>2</sup> (5,500,000 sq mi). Despite being considered a no-men-arrive because of its frigid climate, Antarctica is home to inexhaustible mineral wealth and a fundamental area for natural inquiry. Indeed, although it is unfriendly, it offers invaluable bits of knowledge into the history and show of our world, including ocean level rise, ozone consumption, and climate flow. Researchers take turns investigating its unfamiliar region each year to learn more about natural forms. They look for information that can be followed back a long time or centuries. Specialized inquiries about offices are required to bolster this crucial work. The needs of researchers investigating Antarctica's puzzles are met by these structures, which are twofold as covers and labs [10].

People don't live in Antarctica, but only in laboratories with periodic scientists visiting the continent.

*Europe.* Europe is the second-smallest continent as it is where Oceania has less landmass. Europe amplifies from the island country of Iceland in the west to the Ural Mountains of Russia in the east. Europe's northernmost point is the Svalbard archipelago of Norway, and it comes as distant south as the islands of Greece and Malta.

As a continent, the economy of Europe is right now the biggest on soil, and it is the wealthiest locale as measured by resources beneath administration, with over \$32.7 trillion compared to North America's \$27.1 trillion in 2008.

*South America.* South America is the fourth biggest of the world's continents. The southern parcel of the landmass is called the Modern World, the Western Side of the Equator, or the Americas. The landmass is compact and triangular, broad in the north and decreasing to a point – Cape Horn, Chile-in the south [11]. The most industrialized

nations in South America are Brazil, Argentina, Colombia, and Chile respectively [12].

*North America.* North America is the third most enormous landmass in the world. Numerous individuals know it as the landmass of the US, Canada, and Mexico. But what is considered North America past those nations? There are countless other North American countries, particularly in the Caribbean. North America goes from the North Shaft to the best of South America. Its nations border the Pacific, Cold, and Atlantic seas and are domestic to various societies and dialects. A few little domains in North America are not autonomous states but have a place in other remote countries. They are not recorded here as they are not North American countries [13].

Canada, Mexico, and the US have noteworthy and multifaceted financial frameworks. The US has the biggest economy in the world; in October 2016, the Universal Money Related Support (IMF) assessed North America's GDP per capita to be \$ 41,830, making it the wealthiest landmass in the world, taken after Oceania [14].

## METHOD

An exhaustive literature search was undertaken utilizing databases such as ASCE and Google Scholar, resulting in the download of fourteen publications. After a comprehensive screening procedure, eight publications were removed as they were not connected to the project topic, and six were found to be duplicates. The remaining papers gave valuable insights into the advantages, trends, and issues associated with digital technology adoption in architectural, engineering, and construction (AEC) professions.

The study employs a review approach of choosing samples of the five most currently used digital technologies in AEC and relating them to each continent's first five big economies. Though some countries are not among the first five economies in their continent, they are adopting digital technologies compared to those in the first five large economies. These countries are UAE, Saudi Arabia, Singapore, Netherlands, Turkey, Switzerland, and Denmark [15]. The study adopts large economies in this research to be holistic in review.

The data collected involves identifying publications on the most adopted digital technology in AEC/Civil Engineering using a Web-Base search tool and how these emerging technologies are used in the AEC industry. The review aims to col-

lect qualitative secondary data to evaluate the extent of digital technology adoption and the perceived impediments.

**Section 1 of 2**

**DIGITAL TECHNOLOGY AWARE IN AEC**

This questionnaire is to confirm the awareness of digital technology in architecture, engineering and construction(AEC)

This form is automatically collecting emails from all respondents. [Change settings](#)

**Gender \***

Male

Female

**Country \***

Short answer text

**Continent \***

Short answer text

**Profession \***

Short answer text

**Are you aware of these following? \***

BIM

DIGITAL TWINS

3D PRINTING

GIS

IOT

Other...

**Section 2 of 2**

For AEC professionals

Description (optional)

**Have you use any of the digital technology mentioned at previous section? \***

Yes

No

**If previous answer is yes, kindly list \***

Long answer text

What are the most commonly used digital technology in your area?

Figure 4 – The sample survey form sent for the data collection

The usage of development programs and imaginative development innovations covers all development stages, from venture start to the on-site exercises and the complementation stage.

The AEC computer program is utilized mainly by AEC (engineering, designing, and development) staff for extended administration exercises such as planning, arranging, evaluating, planning, and office administration.

Findings reveal an average utilization of the five most currently used AEC digital technologies in civil engineering.

*Building Information Modeling (BIM)*. BIM encourages the creation of advanced representations of buildings and frameworks' physical and valuable characteristics. It upgrades collaboration, streamlines venture administration, and advances decision-making throughout the project lifecycle [15].

What are BIM Levels? Various BIM levels can be accomplished for different sorts of ventures. Each level speaks to a distinctive set of criteria that illustrates a specific "maturity." BIM levels begin with zero and go to 4D, 5D, and 6D BIM. These levels gauge how successfully or how much data is being shared and overseen throughout the process. So, what does each level include, and how can you distinguish which level you are working? Underneath are brief portrayals of them to begin with three levels and clarify the criteria at each stage [16].

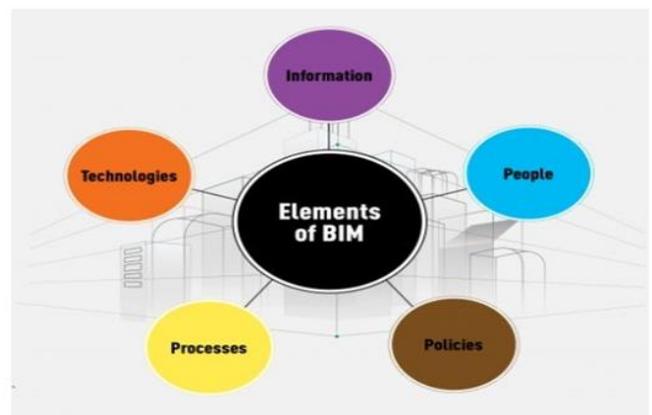


Figure 5 – The elements of BIM credit

*3D Printing*. 3D Printing, also known as added substance fabricating, is an inventive handle for making three-dimensional objects from Computer-Aided Plan (CAD) models. It works on a basic concept called layer-by-layer development. 3D Printing includes fabric in progressive layers to construct a question. This preparation starts with an advanced 3D demonstration outlining utilizing CAD computer programs or through 3D filtering innovations. At that point, the show is cut into various lean, flat layers to make a computerized

outline. These layers direct the 3D printer as it stores fabric, regular plastic, concrete, metal, or other composite materials after the exact enlightenment of the advanced design [17].



Figure 6 – 3D Printing of a building under construction credits and designing buildings

*Internet of Things (IoT).* IoT gadgets, such as sensors and actuators, are used for real-time observation of development destinations; this incorporates following gear use, guaranteeing specialist security, and Optimizing development processes. The Internet of Things (IoT) encompasses everything connected to the Internet, but it is increasingly being used to define objects that "talk" to each other. Have you ever heard the term "Smart device" – smartphones, smart cars, smart thermostats, smart doorbells, smart refrigerators – the list goes on and on [18].



Figure 7 – Showing how IOT works

*Digital Twins.* Creating advanced twins includes reproducing physical structures in a computerized environment; this permits real-time observation, examination, and reenactment, empowering initiative-taking upkeep and improving operational efficiency.

Digital Twins in construction are more than just models; they are dynamic, data-driven tools that revolutionize the industry. From design and planning to real-time monitoring and predictive maintenance, their applications are vast and transformative.

As technology advances, the future of Digital Twins promises even greater integration and AI-driven insights, making them a cornerstone of modern construction practices [19].



Figure 8 – Shows digital twin works credits

*Geographic Information System (GIS).* GIS coordinates spatial information to bolster planning, investigation, and decision-making. In gracious buildings, GIS is connected to urban planning, framework administration, and optimizing the spatial layout of ventures [15]. GIS can utilize any data that incorporates the area. The area can be communicated in numerous ways, such as scope, longitude, address, or ZIP code.

GIS can compare many diverse kinds of data. The framework can incorporate information about individuals, such as population, pay, or instruction level. It can include data from the scene, such as the area of streams, distinctive vegetation, and diverse sorts of soil. It can incorporate data on the destinations of industrial facilities, ranches, and schools, or storm channels, streets, and electric control lines.

With GIS innovation, individuals can compare the areas of distinctive things to find how they relate to each other. For case, utilizing GIS, a single outline might incorporate destinations that create contamination, such as manufacturing plants, and locales that are delicate to contamination, such as wetlands and streams. Such an outline would help individuals to decide where water supplies are most at risk [20].

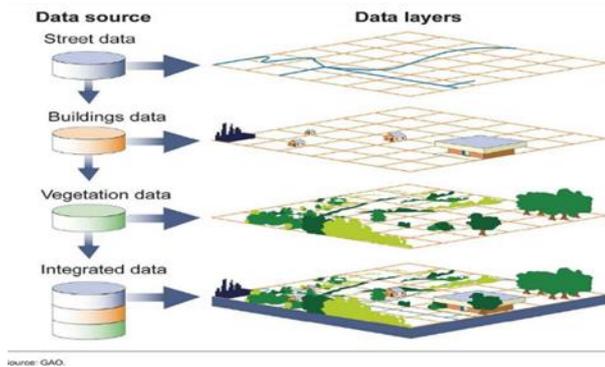


Figure 9 – Shows how GIS works

## RESULTS AND DISCUSSION

1) *The United States*: The US is a frontrunner in bringing computerized innovations into development. Advancements such as Building Information Modeling (BIM), Drones for location looking over, and IOT sensors to screen essential well-being are universally used. Tech centers like Silicon Valley cultivate collaborations between development companies and tech firms, driving headways in development tech.

2) *The United Kingdom*: The UK government has been a solid advocate for appropriating BIM and other advanced apparatuses in development. This has driven the broad use of computerized innovations in industry. The Middle for Advanced Built Britain is a crucial activity aimed at changing the UK's development segment through advanced innovation.

3) *Germany*: Known for its greatness in design, Germany is contributing intensely to computerized development advances. The nation exceeds expectations in coordination and has progressed in fabricating strategies with development, using mechanical autonomy, 3D Printing, and IoT (Internet of Things) gadgets to make more brilliant buildings and infrastructure.

4) *Japan*: The development industry uses innovative innovation to address labor deficiencies and improve productivity. Mechanical technology, AI,

and mechanized apparatus are commonly used on development destinations. Companies like Shimizu Organization have created independent development robots that perform different assignments, from welding to concrete finishing.

5) *China*: China's fast urbanization has urged the need for progress in development. The country is a leader in using AEC; entire buildings are designed off-site and assembled on-site. Furthermore, China is at the forefront of the development of AI, big data, and IoT, leading to notable advancements in efficiency and extended administration.

6) *Australia*: Australia rapidly receives computerized development advances, including BIM, drones, and virtual reality for location arranging and administration. The nation's strong focus on sustainable development

These nations stand for how computerized innovation can revolutionize development, making it more secure, productive, and responsive to present-day needs. As these advances continue, the development division will likely see critical change.

An online survey was distributed, and engineers from numerous continents responded. Up to North America was the, to begin with, among the continent. Nations in Asia see them arranged as slant of edification (realize) in the Buildup Cycle show. In the innovation dissemination demonstration, the fundamental BIM users worldwide were the "early majority" (third arrange). Still, those in the Center East/Africa and South America were "early adopters" (moment arranged). In expansion, more progressed nations tend to use BIM services more frequently. In outline, North America, Europe, Oceania, and Asia were progressing rapidly toward the realized arrangement of BIM. (Research gate)

The data reflect an increasing interest in digital technology. The United States is the most advanced country in adopting digital technology in civil engineering (AEC), followed by China and the UK.

As is clear, the United States of America holds its beat spot for the fifth consecutive year, making it the most geospatially ready nation since 2017.

From a territorial viewpoint, owing to the USA's 1st position and Canada's 5th position (up two places from CGRI-18), the North American locale continues to overwhelm the territorial geospatial preparation for the third straight year. Indeed,

although Mexico and Costa Rica rank moderately in all-inclusive, these nations are taking a few activities to become geospatial-ready [21].

The European landmass is ruling the 3D printing development industry after North America, which is overwhelmed by the USA and Canada; the rate share of the two North American nations is tall compared to the standard combination of the European landmass where South America is the moment slightest after South America.

Digital technology has become popular worldwide to enhance AEC processes and operations. Only a few countries, including South Africa, are at the forefront of its adoption in Africa, while countries like the US, China, Saudi Arabia, Canada, Brazil, and Turkey are leading in adopting digital technologies in AEC in other parts of the world.

Despite the popularization of digitalized advances such as manufactured insights, virtual reality, drones, 3D Printing, mechanical autonomy, keen buildings, keen cities, computerized twins, and the metaverse, Africa is, however, up with this unused concept due to significant variables such as the need of mindfulness of digitalization, destitute control supply, the need of satisfactory computerized preparing offices, tall fetched of computerized framework and need of investigate in digitalization [22].

Most African countries are considered developing compared to countries of other continents, especially Europe and Asia. Europe, for instance, is described as the most developed continent in the world, with all the countries within Europe classified as developed. In contrast, most African countries are considered least developed (LDC). Furthermore, some African countries are considered more developed, with Mauritius, Seychelles, Algeria, Tunisia, Botswana, Libya, South Africa, Egypt, Gabon, and Morocco listed as Africa's top ten most-developed countries. However, despite a population of about 216 million and ranked the largest economy in Africa with a GDP of \$1.14 trillion, Nigeria is still a developing country, including Ghana, Benin, Cameroun, Togo, Kenya, Uganda, Rwanda, and Tanzania.

The rating (1-3) is the time adoption rate of digital technologies such as 1 – Early Adopter, 2 – Second Adopter, and 3 – Recent Adopter.

Table 1 shows that the US, Canada, the UK, and Japan are the early adopters and pioneers of digital technologies in architectural engineering and

construction in terms of countries. Africa, South America, and Oceania (except for Australia) are mostly the late or recent adopters of digital technologies in continents.

Table 1 – Comparison of the digital technologies in each continent with sample nations

Countries	Digital Technology Rating (1-3)					Continent
	BIM	IOT	3d Printing	GIS	Digital Twin	
United States	1	1	1	1	1	North America
Canada	1	1	1	1	1	North America
Mexico	2	2	2	2	2	North America
Dominican Republic	3	3	3	3	3	North America
Cuba	3	3	3	3	3	North America
Germany	2	1	1	1	2	Europe
France	2	1	2	1	1	Europe
Italy	2	2	2	2	2	Europe
United Kingdom	1	1	1	1	1	Europe
Russia	2	2	2	2	2	Europe
South Korea	2	1	1	1	1	Asia
Japan	1	1	1	1	1	Asia
China	2	2	2	2	2	Asia
India	2	2	2	2	2	Asia
Indonesia	2	2	2	2	2	Asia
South Africa	2	2	2	2	2	Africa
Egypt	2	2	2	2	2	Africa
Ethiopia	2	2	2	2	2	Africa
Nigeria	3	3	3	3	3	Africa
Algeria	2	2	2	2	2	Africa
Brazil	2	1	2	2	1	South America
Argentina	3	3	3	3	3	South America
Colombia	3	3	3	3	3	South America
Chile	3	3	3	3	3	South America
Peru	3	3	3	3	3	South America
Australia	2	2	2	2	2	Oceania
New Zealand	2	2	2	2	2	Oceania
Papua New Guinea	3	3	3	3	3	Oceania
Fiji	3	3	3	3	3	Oceania
Solomon Islands	3	3	3	3	3	Oceania

Notes: Top Users (progression, embracing, and adopting) – 1; Mid-users (progression, embracing, and adopting) – 2; Last users (progression, embracing, and adopting) – 3.

Table 2 is an analysis of the adoption rate based on progressions in technologies and economies and how digital innovation in AEC is being utilized and, for the most part, acknowledged in each locale.

Table 2 – Adoption rate based on progressions in technologies and economies and how digital innovation in AEC

Digital Technology	BIM	3D Printing	Digital twins	IOT	GIS
Africa	3	3	3	3	3
Asia	2	2	2	2	2
Europe	1	1	1	1	1
North America	1	1	1	1	1
Oceania	2	2	2	2	2
South America	3	3	3	3	3

Notes: Top Users (progression, embracing, and adopting) – 1; Mid-users (progression, embracing, and adopting) – 2; Last users (progression, embracing, and adopting) – 3.

This information is obtained through an intensive look at journals, articles on websites, and the utilization of online search tools. The table audit shows that North America (USA, Canada) and Europe (UK, Germany, and France) are the pioneers, early adopters, and overwhelming spenders on advanced innovations, whereas Asia (Ja-

pan, South Korea, and China) and Oceania (majorly Australia) are second-level adopters. South America (except Brazil, a second-level adopter) and Africa are the late or later adopters.

The numbers in each continent column also show how frequently the technologies are embraced and used effectively and commercially in architecture, engineering, and construction.

## CONCLUSIONS

The research shows a pressing need for AEC education to adapt to business demands. It recommends increasing educational offerings to embrace immersive technology and encourage a culture of creativity that is against the traditional method of the construction process. The study concludes as follows. North America and Europe are the forerunners of digital technologies in terms of pioneering and adoption. Asia and Oceania are mid-level adopters of digital technologies, and China from Asia is growing faster than most nations. South America and Africa are the late adopters of digital technologies.

Future studies should focus on longitudinal studies to follow the progress of technology use and its influence on the AEC sector. A standardized curriculum with digital capabilities is also needed to train future professionals in the digitalized AEC sector.

## REFERENCES

1. Sawhney, A., & Knight, A. (2023). *Digitalization In Construction Report 2023*. London: The Royal Institution of Chartered Surveyors.
2. Puolitaival, T., Kestle, L., & Kähkönen, K. (2018). *What's The Real Story Around Digital Technologies In Construction Management?* Retrieved from [https://www.researchgate.net/publication/359106894\\_What's\\_the\\_real\\_story\\_around\\_digital\\_technologies\\_in\\_construction\\_management](https://www.researchgate.net/publication/359106894_What's_the_real_story_around_digital_technologies_in_construction_management)
3. Brozovsky, J., Labonnote, N., & Vigren, O. (2024). Digital Technologies In Architecture, Engineering, And Construction. *Automation in Construction*, 158, 105212. doi: 10.1016/j.autcon.2023.105212
4. Sepasgozar, S. M. E., & Davis, S. (2019). Digital Construction Technology and Job-site Equipment Demonstration: Modelling Relationship Strategies for Technology Adoption. *Buildings*, 9(7), 158. doi: 10.3390/buildings9070158
5. Miró, J. M. (2021). *In Which Countries Is BIM Mandatory for Public Projects?* Retrieved from <https://www.archdaily.com/956398/in-which-countries-is-bim-mandatory-for-public-projects>
6. Othman, U. (2023). *Leapfrogging into the Digital Era: Can the African Construction Industry do it?* Retrieved from <https://www.linkedin.com/pulse/leapfrogging-digital-era-transforming-african-uboho-yahaya-othman>

7. Augustyn, A. (2024, July 29). Continent. Retrieved from <https://www.britannica.com/science/swamp>
8. Boudreau, D., McDaniel, M., Sprout, E., & Turgeon, A. (2023). *Asia: Physical Geography*. Retrieved from <https://education.nationalgeographic.org/resource/asia/>
9. Wikipedia. (2024, June 29). Asia. Retrieved from <https://en.wikipedia.org/w/index.php?title=Asia&oldid=1231582655>
10. Boudreau, D., McDaniel, M., Sprout, E., & Turgeon, A. (2023). *Antarctica*. Retrieved from <https://education.nationalgeographic.org/resource/antarctica/>
11. Ramos, V. A., Griffin, E. C., Avila, H. F., Germani, G., Minkel, C. W., Dorst, J. P., Daniel W. G., & Knapp, G. W. (2024). *South America: References & Edit History*. Retrieved from <https://www.britannica.com/place/South-America/additional-info#contributors>
12. Wikipedia. (2024). South America. Retrieved from [https://en.wikipedia.org/wiki/South\\_America](https://en.wikipedia.org/wiki/South_America)
13. Blakeley, S., & Cheprasov, A. (2023, November 11). *North America. History, Countries & Capitals*. Retrieved from <https://study.com/learn/lesson/countries-north-america-capitals.html>
14. Wikipedia. (2024, July 3). North America. Retrieved from [https://en.wikipedia.org/w/index.php?title=North\\_America&oldid=1232334834](https://en.wikipedia.org/w/index.php?title=North_America&oldid=1232334834)
15. Islam, I., Vishakha, & Vikram, A. (2024). Smart Cities And Civil Engineering: Integrating Technology For Urban Development. *International Journal of civil engineering and technology (IJCIET)*, 15(1), 19–20.
16. Lorek, S. (2022). *What is BIM (Building Information Modeling)?* Retrieved from <https://constructible.trimble.com/construction-industry/what-is-bim-building-information-modeling>
17. JKCement. (2024, March 22). *Understanding The Utility Of 3D Printing In Construction*. Retrieved from <https://www.jkcement.com/blog/construction-planning/3d-printing-in-construction/>
18. UC Santa Cruz. (2020, August 19). *Internet of Things*. Retrieved from <https://its.ucsc.edu/news/internet-of-things.html>
19. Sharon M. (2023, September 22). *Exploring Digital Twins in Construction*. Retrieved from <https://medium.com/@matt-sharon/exploring-digital-twins-in-construction-f8467d1f37c4>
20. Evers, J. (2024). GIS (Geographic Information System). Retrieved from <https://education.nationalgeographic.org/resource/geographic-information-system-gis/>
21. Kapoor, S. B., & Narain, A. (2019). *Which Is The Most Geospatial Ready Country In The World?* Retrieved from <https://www.geospatialworld.net/article/which-is-the-most-geospatial-ready-country-in-the-world/>
22. Designing Building. (2023, March 21). *Digital construction future for Africa now*. Retrieved from [https://www.designingbuildings.co.uk/wiki/Digital\\_construction\\_future\\_for\\_Africa\\_now](https://www.designingbuildings.co.uk/wiki/Digital_construction_future_for_Africa_now)
23. Wikipedia. (2024, June 30). Africa. Retrieved from <https://en.wikipedia.org/w/index.php?title=Africa&oldid=1231799092>