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# Use of automation and artificial intelligence as a sub-set of knowledge management domain in architectural organisations in South Africa

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## Abstract

*The purpose of this paper is to publish research findings on the use of automation and artificial intelligence as a sub-set of knowledge management domains in architectural organisations in South Africa. Automation and artificial intelligence are two aspects that the fourth industrial revolution deals with, and automation may drastically change the way humans work.*

*For this paper, research data was collected by means of a qualitative research study. Consisting of 14 semi-structured interviews. The paper presents a discussion and research on the use of automation and artificial intelligence in the service architectural organisations provide.*

*The research findings indicate that automation and artificial intelligence may, in the near future, have an impact on this service provision, even if the use of automation and artificial intelligence is currently not commonly used. These research findings are useful and important in education as these findings are new and may practically affect future curricula; to meet industry needs and changes pertaining to the fourth industrial revolution, and to remain relevant and provide appropriate skill enabled graduates.*

***Keywords***: Architectural organisations, artificial intelligence, automation, fourth industrial revolution, knowledge management

## Introduction

This paper emanates from a Master of Business Leadership (MBL) research report completed by one of the authors of this paper and supervised by the other author of this paper. Data and analysis referred to within this paper, comes from and is included within, this submitted but unpublished MBL dissertation.

When referring to Architects and architectural organisations confusion may arise. This paper includes a study focused on built environment Architects and architectural organisations. Architectural organisations employ Architects, Architectural Technologists, and Architectural Draughts people, most of whom enter the workforce after graduating from design higher learning institutions, specifically schools of Architecture, Planning, and Interior Design. These employees and shareholders execute Architectural Projects as set out according to the South

 

African Council for the Architectural Profession (SACAP) Board Notice 91 (2020), Stages of Work for Architectural Projects.[34]

This paper presents research findings of semi-structured interviews on the use of automation and AI in the service architectural organisations provide. These research findings are useful and important in education as these findings are new and may practically affect future curricula in schools of Architecture, Planning, and Interior Design. These future curricula developments may be necessary to meet industry needs and changes pertaining to the fourth industrial revolution, so that schools of Architecture, Planning, and Interior Design can remain relevant and provide appropriate skill-enabled graduates.

For this paper, it is important to know what definition each term refers to. The term knowledge management (KM) refers to the action of managing knowledge (Aggestam, 2006; Grover & Froese, 2016). This KM action can be further elaborated upon as the acquisition, creation, sharing, and transfer of information (Pinho, Rego & e Cunha, 2012). Once KM has support from an information technology system, it is referred to as a knowledge management system or knowledge management systems (KMs). Organisations, such as architectural organisations, may use KMS for the capture, storage, retrieval, and usage of knowledge within that organisation (Sivasubramanian, 2016). The most common KMS used by architectural organisations are computer-aided draughting (CAD) software enabled building information modelling (BIM).

For lack of space and brevity other seminar sources on theory and practice of knowledge management have not been reported on. These are found elsewhere with Afolayan, White and Mason-Jones (2016), Barrat (2013), Desouza (2002), Ghahramani (2015), Gorry (2014), Omotayo (2015), and Schapire (2008).

A knowledge worker (KW) is a person whose job involves handling or using information. A KW has knowledge of a subject matter and is employed in a field where they use this knowledge (Serrat, 2017). A KW gains greater knowledge power (KP) when they receive appropriate knowledge resources. KMS may assist an architectural organisation KW employee to enhance their KP above and beyond the KP they already have due their qualification and experience. KP refer to the control of unique information (Burnes, 2014), usually information that is necessary for decision making. Therefore, enhanced KP improves the effectiveness of architectural organisation KW employees.

Architectural organisations, in their execution of built environment projects, deal with big data. Big data refers to the analysis and handling of massive datasets (Mashey, 1997). Data sets that may be analysed by performing a procedure of calculating or determining something by mathematical or logical methods. This is done with the aim of revealing patterns, associations, and trends. These patterns, associations, and trends may be automated and inform artificial intelligence (AI) to predict the most probable next step, thereby supporting architectural organisation KW employees or possibly even, eliminating, augmenting, or changing the work roles of some architectural organisation KW employees.

AI refers to the solving of complex problems by means of intelligence exhibited by an artificial entity (Borana, 2016). AI deals with innovations and developments relating to computers and machines having human-like intelligence, which is characterised by cognitive abilities, learning, adaptability, and decision-making capabilities (Chen, Chen & Lin, 2020). As

[34] The South African Council for the Architectural Profession (SACAP) Stages of Work for Architectural Projects consist of: 1: Inception. 2: Concept and viability. 3: Design development. 4: Documentation and procurement. 5: Construction. 6: Close out (SACAP Board Notice 91, 2020).

Automation and AI are two aspects that the fourth industrial revolution (4IR) deals with, it is therefore important to discuss the 4IR.

The 4IR is upon us (World Economic Forum, 2016) and the impact of the 4IR on worker displacement, as well as encouraging new strategies for empowering job transitions, from declining to emerging roles, have accelerated since 2016 (World Economic Forum, 2018, World Economic Forum, 2020). Many industries are already (Kim, 2019, McKinsey, 2017), and most industries may in future (Kim, 2019; World Economic Forum, 2016; Frey & Osborne, 2013), be affected by the 4IR. This includes architecture and the construction industry (Frey & Osborne, 2013). The 4IR deals with digitisation (Hirschi, 2018; Schwab, 2016) and automation enabled by advances in robotics, AI, and machine learning (McKinsey, 2017). Automation may drastically change the way humans work (McKinsey, 2017; Frey & Osborne, 2013).

These drastic changes in the way humans work, associated with automation, which may affect architectural organisation KW employees consist of: Online globalised crowdsourcing of high-skilled but repetitive work processes, a rise in time limited, project-based contracts (World Economic Forum, 2016) expanded use of contractors for task-specialised work (World Economic Forum, 2020), and the use of remote staffing and decentralisation of operations (World Economic Forum, 2018, World Economic Forum, 2020). Furthermore, employees may be required to have a much higher level of technology literacy than in the past, greater problem-solving skills, and broader general understanding of the work processes of their organisation (World Economic Forum, 2016).

The World Economic Forum (2020) state that there is a need for tangible evidence and reliable information from the frontlines of this change. The authors of this paper were placed in a position to observe the dynamics of architectural organisations and to ask the participants to the study to reflect on the latest employment, skills, and human capital investment trends in their industry. It is therefore important to list and discuss these industry changes and emerging industry needs regarding automation and AI.

## Research methods

There is limited, to no research on the industry changes and emerging industry needs regarding automation and AI for architectural organisations in South Africa. Likewise, there is limited, to no research available on how these organisations may adapt to the 4IR. To address this limitation of available research this paper presents a discussion and research on the use of automation and AI in the service architectural organisations provide.

### *A qualitative research approach*

A qualitative research study, consisting of semi-structured interviews, was employed as a method of inquiry into the status and practices of architectural organisations. A qualitative research approach was chosen for this study as the kind of information used for this paper deals with the specific phenomenon (Blumberg, Cooper & Schindler, 2014) of KM, automation, and AI in architectural organisations.

### *Population and sample framework*

The population and sample framework interviewed consisted of architectural organisation KW employees, shareholders, and schools of Architecture, Planning, and Interior Design Senior Lecturers. In 2019 when the research data was submitted the population of Professional Senior Architectural Technologists and Professional Architects in Gauteng consisted of 2458

 

professionals of which 1642 are Professional Architects (SACAP, 2017). From this population a sample unit of 14 participants was selected consisting of participants who fit an identified criterion.

The criteria list requirements such as years of experience whereas a participant must have a minimum of 10 years' experience in an architectural organisation or school of Architecture, Planning, and/ or Interior Design; a position of seniority in their organisation; and an interest in KM, automation and AI. This study therefore targeted and approached middle management participants, who hold positions such as team leaders, team managers, and associates. The study also targeted owners, leaders, and directors of architectural organisations who make decisions on the day-to-day running of the architectural organisation as a business. Furthermore, experienced Senior Lecturers at schools of Architecture, Planning, and Interior Design have been included.

*Sample units*

Sample units are the units, or in the case of individual participants, the participants, as chosen by the sampling selection (Diamantopoulos & Schlegelmilch, 2000). The sample units consisted of 14 qualified participants who showed an interest to be interviewed and who fit the criteria of the sampling selection. The demographic was made up of the four identified sub-population or strata groups, namely:

- Group 1 Directors/company owners, 5/14 participants or 36% of the study;
- Group 2 Associates/team leaders, 3/14 participants or 21% of the study;
- Group 3 Architectural institute leaders, 3/14 participants or 21% of the study; and
- Group 4 Schools of architecture, planning, and interior design senior lecturers, 3/14 participants or 21% of the study.

*Sample unit gender*

At least one participant in each group was female. There are far fewer female architectural professionals than male architectural professionals in South Africa (SACAP, 2017). A decision was made to include 36% female participants, as this was an above average female representation of the profession. Thereby an attempt toward gender parity was made without misrepresenting the current unequal state of the profession.

*The research instrument*

According to Leedy and Ormrod (2015), a criterion of a phenomenological study is that participants must all have direct experience with the phenomenon being studied. In this case KM, automation, and AI in architectural organisations. Leedy and Ormrod (2015) go on to state that the exploratory methods of a phenomenological study lend itself almost exclusively to lengthy interviews consisting of one to two hours. For these interviews a small sample of participants consisting of five to 25 individuals, is arguably applicable. For this research, interviews were conducted with one participant at a time.

It is noteworthy that the research presented in this paper originates from a larger business study that collected data on the topics of KM, automation, and AI in South African architectural organisations, as project-based organisations. Questions on automation and AI were concluding questions to the interviews. It was thought applicable to enquire about automation and AI as automation and AI are sub-sets of KM. The data collected on AI and automation was thought significant enough by the author to share in a publication.

 

There were eleven questions in total. Question 10 and 11 receptively being (van Tonder, 2019, pp. 114):

> *10) Do you automate any of your service provision?*
>
> *11) Do you think that it is possible to automate architecture and use artificial intelligence to provide the service or part of the service that architectural organisations currently provide?*

## Research results

The research findings indicate that automation and AI may, in the near future, have an impact on the service that architectural organisations in South Africa provide. However, it is important to note that automation and AI is currently not commonly used. Furthermore, the research findings indicate that KM and KMS may be the vessel for architectural organisations to weather the storm of the 4IR. A revolution that is eminent and therefore architectural organisations may consider adapting, to retain a competitive advantage. Likewise, schools of Architecture, Planning, and Interior Design may find these research findings useful and important in education as these findings are new and may practically affect future curricula.

Data was collected and captured appropriately for data analyses. The results are presented in categories of themes.

### *Automation*

The participants in the study were asked if they or the architectural organisation they are involved with automating any of their service provision. Five of the 14 participants or 36% of the study stated 'yes', two participants or 14% of the study stated 'no,' and seven participants or 50% of the study were unsure. Figure 1 below shows the results (van Tonder, 2019).


Figure 1: Architectural organisations automation of service provision chart

KW employees spend a notable amount of time on administrative work, such as timesheets, contracts, and invoices. Automation could indicate a saving on allocated work hours as repetitive tasks may be minimised. However, one participant who is a director of a small architectural organisation explained that the cost of automation to perform a task such as an invoice, is not justifiable as they only produced one to three invoices a month and therefore do those manually. The work hours for that specific task are still cheaper than the initial cost of automation (van Tonder, 2019).

Of the 14 participants, one of the five participants who answered 'yes' is a director of a small architectural organisation. They stated that they extensively use CAD software that enabled

BIM to capture as much knowledge from previous projects as possible for use on future projects. They stated that they preferred producing or drawing a piece of information only once. Of all the participants, this was the only participant who did not consult other KW employees to enable KM as they used their CAD software enabled BIM as a knowledge management system (van Tonder, 2019).

One participant, a school of Architecture, Planning, and/or Interior Design Senior Lecturer stated, regarding CAD software enabled BIM as KMS, that the onus is on the schools to provide an education to students and that the onus is on industry to provide training to recently graduated candidates. Therefore, even though CAD software enabled BIM is part of the coursework the emphasis is not on training.

*Automating architecture*

Participants were asked if they thought it possible to automate architecture. Eight of the 14 participants or 57% of the study stated 'yes', it is possible, five participants or 36% of the study stated 'no' it is not possible, and one participant or 7% of the study had no comment (van Tonder, 2019). Figure 2 below show the results.


Figure 2: Possibility to automate architecture chart

According to Grover and Froese (2016) the construction industry shows low levels of productivity because the same errors occur from project to project. Automation as part of KM and KMS mitigate these mistakes and reduce the cost thereof from project to project. Therefore, it is interesting to know to what extent architectural organisations use the automation of architecture in the service they provide.

It is noteworthy that some participants stated that Microsoft Excel, and Microsoft Outlook calendar are information technology tools that they perceive to be the automation of architecture, even though it is not (van Tonder, 2019). One participant stated that automation of architecture for them would be when the CAD software they work on has the intelligence to know which SACAP Stage of Work for Architectural Projects a specific project is at, and thereby log the hours they work on the project, on the CAD software, automatically onto the timesheet. It is therefore deduced that the participants had a different understanding of what automating architecture may entail (van Tonder, 2019).

Cognisance may be taken of the way this question was posed in the interviews. The question, 'Do you think that it is possible to automate architecture and use AI to provide the service or part of the service that architectural organisations currently provide?' was read as a whole, and then broken down and asked in two parts. The first part of the response to the question was tallied separately from the second part. The first part being 'Do you think that it is possible to automate architecture to provide the service or part of the service that architectural organisations currently provide'. The second part of the question was 'Do you think that it is possible to use artificial intelligence to provide the service or part of the service that

 

architectural organisations currently provide?' (van Tonder, 2019). Therefore, the results to the question of automating architecture pertain to automation providing the service or part of the service that architectural organisations currently provide, and not automating architecture as a whole and thereby replacing, augmenting, or complementing, the professional service that Architects provide in its completeness.

It was unclear if any of the participants or the architectural organisations they are involved with, have made any real advancement in automating architecture. Four participants, all from the same large-sized architectural organisation, mentioned a research and development initiative explored over the past two years by their organisation, towards automating architecture for Stage 2 of the SACAP Stages of Work for Architectural Projects. However, one participant believed that the project came to a halt and was unsuccessful. The remaining three believed the project was necessary, showed great potential, but were unsure whether it would prove successful. Unfortunately, none of the participants worked directly with, was involved in, or contributed to, this research and development project (van Tonder, 2019).

One participant, a school of Architecture, Planning, and/or Interior Design Senior Lecturer stated regarding the automation of architecture that a knowledge repository of say generic construction and building details is detrimental to the learning and discovery of students, who are tasked with designing their own details. The participant agreed that in practice information should not be regenerated at a cost, if it is not necessary, but that during education discovery is an important process deterred by having generic information at hand.

*Artificial intelligence*

There is limited information on AI in architectural organisations. Therefore, participants were asked if they think it possible to use AI to provide the service, or part of the service, that architectural organisations currently provide.

Six of the 14 participants or 43% of the study stated 'yes', it is possible, two participants or 14% of the study stated 'no' it is not possible, and six participants or 43% of the study stated, 'not really', 'it depends', they 'are unsure', or 'no comment'. Arguably only 14% firmly stated 'no' with 43% acknowledging the possibility of AI playing a role in architectural organisations, and a further 43% reluctant to commit to either a 'yes' or a 'no' (van Tonder, 2019). Therefore, it could be argued that 86% of the study already realise that AI may be a future factor for architectural organisations to take into account, as the participants do not immediately dismiss the possibility. Figure 3 below show the results.


Figure 3: Possible for AI to provide the service that architectural organisations provide chart

According to Pannu (2015) AI can perform certain tasks more effectively than a human being can. KM, automation, and AI may contribute to reducing the work hours or KW employee resources, currently allocated to the service provision that architectural organisations provide.

 

Thereby providing a strategic advantage to architectural organisations by enhancing effectiveness (van Tonder, 2019).

It is important to note that the impact of AI in architectural organisations is currently unmeasurable as AI is not yet an innovation that is used in architectural organisations. AI in architectural organisations is currently only in the beginning stages of conceptualisation and development, or currently architectural organisations are only speculating the possible benefits of AI.

automation and AI could be a significant strategic advantage for architectural organisations and the driving force behind the required business survival sustainability for architectural organisations in South Africa. As a paradox, the reason automation and AI as an innovation is nearly unexplored, is that such research and development is costly. Due to low or no profit margins for architectural organisations, there are limited or no funds to spend on research and development. Schools of Architecture, Planning, and Interior Design may play a role by providing some of the necessary research and development.

The use of automation and AI may also come at the cost of a loss of employment for some KW employees. As South Africa deprecates to more than 16 million people who are unemployed (Statistics South Africa, 2019) an innovation that may come at the cost of jobs may be socially and morally irresponsible.

*Changes for knowledge worker employees*

Participants were asked if they think the successful automation of architecture would cost architectural organisation KW employees their employment. Two participants or 14% of the study said 'yes', that automation of architecture would probably cost some people their jobs. A further two participants or 14% of the study maintained that the automation of architecture is not possible. The remaining 10 participants or 71% of the study answered 'no', architectural organisation KW employees would not lose their jobs, their jobs may change or evolve and that new job descriptions in architectural organisations would emerge (van Tonder, 2019). Figure 4 below show the results.

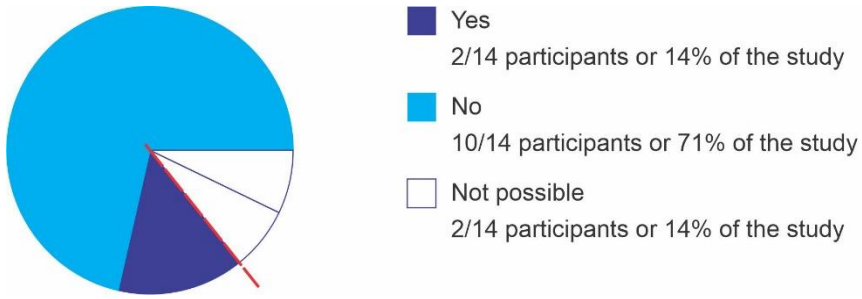


Figure 4: Architectural organisation knowledge worker employee job security vs architecture automation chart

71% of the participants argue that a change for KW employees is underway because of automation. Only 14% of the participants stated there may be a loss of employment for KW employees should the automation of architecture ever prove successful. The data shows that the impact on job security may be minimal, which is an argument towards, and for, the use of automation (van Tonder, 2019). These findings are interesting as they align with the drastic changes in the way humans work, associated with automation, which may affect architectural organisation KW employees, previously listed from the World Economic Forum (2016, 2018, 2020).

 

It is suggested that schools of Architecture, Planning, and Interior Design investigate and identify what these changes in the job description may be, how jobs in architectural organisations may change and evolve, as this may impact the future curricula development of schools of Architecture, Planning, and Interior Design. As the effectiveness of architectural organisations KW employees may become the greatest force that determines the profitability of the industry, it is recommended by this paper that graduates from schools of Architecture, Planning, and Interior Design should be informed on topics of KM, automation, AI, and the 4IR, as these topics may have a substantial effect on the industry in the near future.

## Conclusion

The purpose of this paper is to contribute to the body of existing research by publishing research findings on automation and AI and how this may, in the near future, have an impact on the service provision that architectural organisations provide. The research findings are useful and important in education and may practically affect future curricula, as it shows that most of the participants agree that automation and AI is not yet commonly used by architectural organisations in South Africa. Therefore, it is argued that there is still time to prepare; so that schools of Architecture, Planning, and Interior Design may meet industry needs and changes pertaining to automation, AI, and the 4IR, and thereby remain relevant and provide appropriate skill enabled graduates.

*As a summary the following salient points are noted:*

- Drastic changes associated with automation may affect the way architectural organisation KW employees work, and may also affect their job descriptions to change and evolve to include emerging roles;
- Due to automation, graduates may enter the workforce in different ways than what was previously the norm. As opposed to full time, centralised operations, and salaried employment, graduates may be employed on time limited, project-based contracts that comprise decentralised operations;
- Schools of architecture, planning, and interior design may have the opportunity to provide post-exit-level training to graduates, to enhance technology literacy, problem-solving skills, and a broader general understanding of the work processes of architectural organisations; and
- Schools of architecture, planning, and interior design may have the opportunity to provide some of the research and development requirements for KM, KMS, automation, and AI to give advancements towards automating architecture, that may possibly contribute build environmental solutions towards addressing the current global ecological breakdown.

*Future research questions emerge because of this study:*

- Should schools of Architecture, Planning, and Interior Design contribute to the research and development requirements of KM, KMS, automation, and AI?
- What would advancements in automating architecture look like, and what may it require from schools of Architecture, Planning, and Interior Design?
- How are KM and KMS used by schools of Architecture, Planning, and Interior Design amidst the COVID-19 pandemic?

 

- Could automation, AI and the 4IR aid schools of Architecture, Planning, and Interior Design, as well as architectural organisations, to address the current global ecological breakdown better?

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