A systematic literature review of the agile methodology applied during construction project design

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Abstract

The civil construction industry is diverse as it includes various clients like property builders, property engineers, material providers, and contractual workers. The construction industry brings cost-viable building improvements wherein every one of these clients has a dynamic role to make the contract and project a success. The construction industry plays an important role in the infrastructure and economy of a country as well as the livelihood of people. Most infrastructure projects throughout the civil engineering industry, are struggling with cost and schedule overrun which can be caused by various internal and external factors.

This paper aims to determine the possibilities of using agile methodologies in the design phase of a civil engineering project to mitigate cost and schedule overrun and to improve the delivery of the design phase. A systematic literature review was conducted using nine electronic databases, which produced 2440 articles. After conducting the systematic literature review, 22 articles were used for synthesis and analysis. The results of the research identified four challenges faced in the design phase, which included schedule and cost overrun; construction waste management; design performance; and project management. The results obtained indicated that agile methodologies can improve delivery in the design stage of a project.

Keywords

Agile methodology; construction projects; design phase; improve the delivery

1. Introduction

The infrastructure industry is an important industry for a developing country, for improving the economy and providing better infrastructure for the improvement of people livelihood [1]. Civil engineering projects are responsible for the design, construction, and maintenance of infrastructure projects varying from roads, hospitals, airports, treatment plants, power plants, stadiums, dams, and bridges just to name a few [2]. Infrastructure development faces a host of problems where the loss of investments has become a contingency which is factored into the building of the infrastructure projects [1]. Civil construction industries worldwide struggle to deliver projects to the client at the contracted time within the contractual budget, due to the increase in complexity of projects and the rapidly evolving, innovative technologies and requirements from the client [1], [2]. Civil engineering consultants and contractors who do not keep up with the pace of technology will most likely find themselves losing capital to their competitors.

In South Africa, almost 13% of the nation's budget in 2017 was allocated to infrastructure development [3]. As civil engineering projects continue to run into cost and schedule overrun, the delivery of optimum infrastructure within the allocated budget becomes a serious issue [4]. Civil engineering projects need to improve due to the amount of investment that is entrusted to the industry. As the design phase plays an important role in improving the challenges faced by the civil construction industry, more attention should be paid to the design process as a way of optimisation. Agile methodologies focused on people, client and the final product can assist the improvement of efficiency in the design phase of a construction project which in turn can improve delivery.

This paper aims to determine if agile methodologies can improve the delivery of the design phase of a civil construction project. This paper investigates the challenges generally faced in the design phase of a civil construction project and to determine how agile methodologies can address these challenges. This paper is structured as follows: Section 1 provides a brief background on civil construction phases and agile methodologies. Section 2 discusses the research method followed in this study where Section 3 discusses the results obtain and in Section 4 will discuss the analysis of the results followed by Section 5 discussion, and finally, Section 6 will conclude this paper.

1. Related work

1.1 Project Phases in Civil Engineering Projects

Most civil engineering projects, if not all are managed using traditional methods which are linear and rigid. The traditional method's philosophies are deducted from the PMBOK [5], shown in Figure 1.

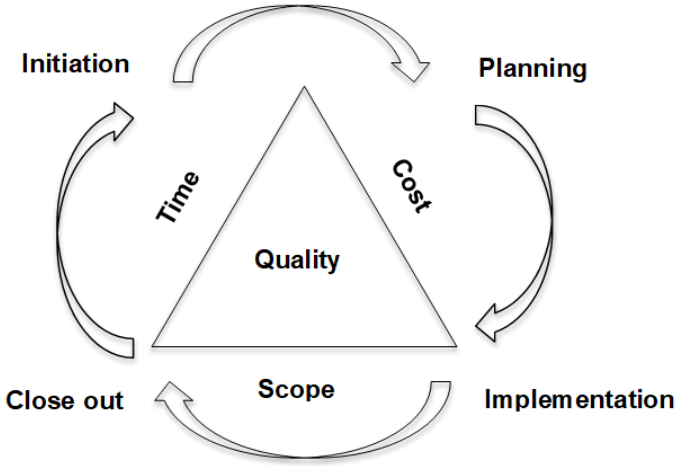

Figure 1: Lifecycle of a civil engineering project

The initial stage of the lifecycle is where the scope of the project is discussed and specifications are drawn [5]. Contracts are drawn at this initial stage and the deliverables are clearly stated by the client. The next phase, called the planning phase, involves the creation of documentation which will assist the design team throughout the entire project. The execution phase deals with the design developments and all construction activities which execute all the requirements and specification from the initial phase [5]. The final stage relates to the closing out and handover, which is the accumulation of the process.

In the initiation and planning stage, the number of risks and uncertainty are of a high degree. It is this stage of the project that identifies the business's risks and opportunities and formulates an appropriate response to mitigate these risks and to take advantage of the opportunities [6]. It is at this stage, therefore, where a feasibility study will be conducted to investigate solutions. Upon completion of the feasibility study, the client can decide whether the project is feasible and whether there is enough justification for it. In the early stages of a project when the uncertainty is high, many changes can occur with the client changing his mind regarding requirements due to new information, these changes do not have a significant effect on the budget [9]. However, as the project progresses, the changes should be reduced to reduce the risk and uncertainty because the cost of change increases as the project progresses. This trend is illustrated in Figure 2 [7].

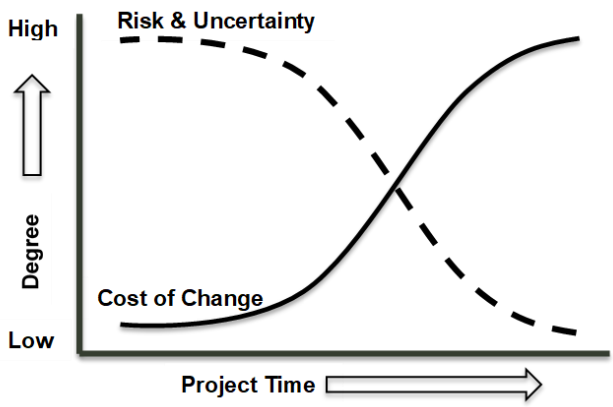

Figure 2. Impact of Variables based on project time (adapted from [7])

According to Harris and McCaffer [8], the influence of the client is very high in the predesign and design phases as there are a large number of alterations with designs. The influence of the change in the project by both client and engineer has, a similar effect to that of Figure 2 wherein the design phase the influence can be high, but when it gets into construction, the influence must be limited to the set documents and plans produced as indicated in Figure 3 [8].

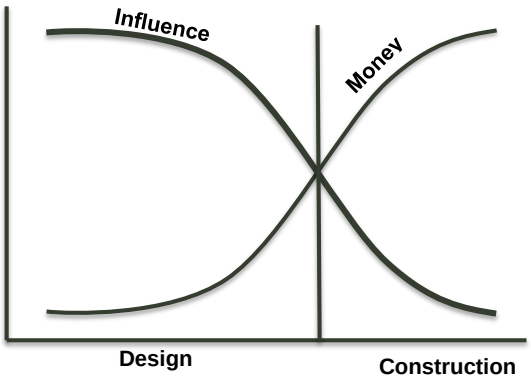

Figure 3. Impact relationship between Influence, cost and Design, Construction

1.2 The design phase of a Civil Engineering Project

The interaction between client and designer is very crucial during the design phase as many issues may arise during this phase [9]. Issues may arise due to the multi-disciplinary groups that are involved in the design phase which need to be carefully integrated for the success of the project. Most challenges that are experienced in the design phase are due to collaboration or lack thereof between client and designers and between the various design teams. Changes in design can be one of the main causes of cost and time overrun in civil construction projects and can result in design errors and errors in plans if not properly updated [10]. According to Li et al [11], there is not enough training conducted by the design team organizations to assist designers and project managers to handle design changes and mitigate design errors.

1.3 Agile Methodology

The agile manifesto [12], designed in 2001, is rooted in a value statement with four core values, namely [13]:

1. *"Individuals and interactions" "over "processes and tools":* Responding to the bureaucracy of current management that is more concerned about the figures and organisational processes than the people.
2. *"Working software" over "comprehensive documentation":* Reacting to the amount of documentation required at each stage of the project, which sometimes gets in the way of the final product developed.
3. *"Customer collaboration" over "contract negotiation":* Emphasising client interaction to better produce the client requirement, and to get more client satisfactory

4. *"Responding to change" over "following a plan": R*esponding to the rigid and linear, conventional method that makes it difficult to make changes even if they are warranted

From these four core value statements, 12 value principles were developed [12]. These principles aimed to make the satisfaction of the client the highest priority by producing early and continuous software value. It states that changing requirements, even late in development, must be harnessed to the advantage of the customer. The strategy speaks to deliver working software on a frequent basis (weekly to monthly) in the shortest time possible where the people form business and development houses work together throughout the project. Agile methods aim to support and trust motivated individuals to get the work done and to provide them with an environment of support to do so. The methodology values face-to-face engagements for conveying information. The agile methodology uses working software as their main measure of progress and promotes continuous technical excellence, good design and simplicity. Teams are promoted to self-organise and regular reflection of the teams are encouraged.

When considering these principles of agile methodology, it can be seen that many of these values are essential in the early design phases of a civil project. Therefore, the investigation into the possibility of harnessing some of these principles in the implementation of the design phase of a civil engineering project is investigated.

2. Research Method

The systematic literature review was used as the method of combining evidence from previous to current scholarly work by extracting journal articles and academic [14]. The systematic literature review differs from the traditional review mainly on process and biasness, where the systematic literature review gives more trustworthiness and credibility [14]. This process follows a prescribed rigorous process which enables duplication. The protocol and process followed were deducted from the Cochrane handbook for systematic reviews of intervention, including the national institute of health [12], [13]. The process followed in the systematic literature review is depicted in figure 4 and discussed in the sections below.

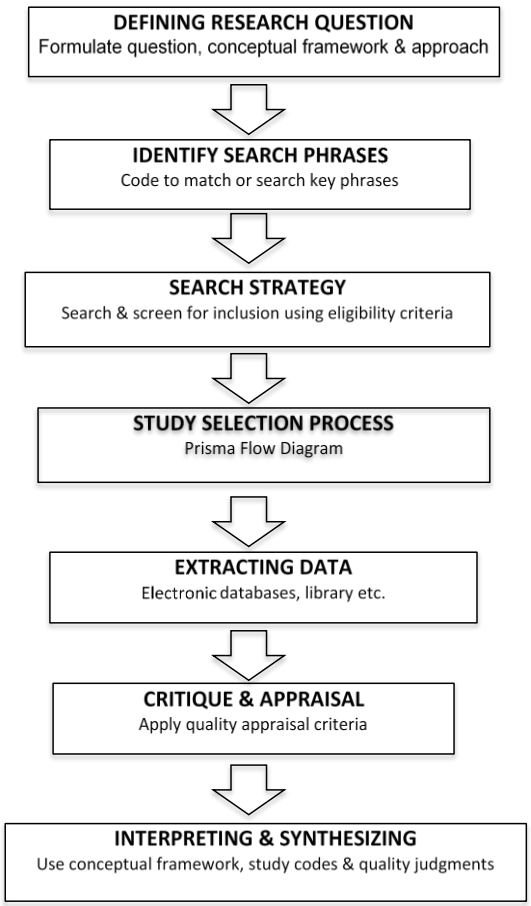

Figure 4. Systematic literature review process

1.2 Research question and search phrases

The definition of the research question was facilitated according to the Cochrane handbook for systematic reviews of intervention. The PICO model, short for "population", "intervention", "comparative intervention," and "outcome" assisted in the extraction of key phrases to use in the search for articles using the electronic databases [17]. The identification of the key search phrases was used to extract a combination of words for the search keys to be used when searching for articles and papers. The key and expanded search phrases from the PICO model were to create a broader search is shown in Table 1.

Table 1. PICO model and expanded words

P	I	C	O
Civil construction projects	Design phase challenges	Agile and Traditional methodologies	Design phase improvement
Engineering projects	Design phase	Agile methodologies	Optimum design
Construction projects	Design challenges	Waterfall methodologies	Design success factors
Infrastructure projects	Planning stage challenges	Agile management	Design performance
Building projects	Design errors	Waterfall management	Best design

2.2 Search strategy and selection process

The search strategy defined the criteria for acceptance of the studies extracted using the key phrases shown in Table 1. The inclusion and exclusion criteria apply to all studies extracted from the electronic database and in any other forms at which it was obtained. The inclusion and exclusion criteria, shown in Table 2, can be applied in different stages of the studies extracted, but it must be done before the final synthesising and analysis.

Table 2. Exclusion and Inclusion Criteria's

Exclusion	Inclusion
Sources	
Papers, books, any material not in English	Peer-reviewed articles
Material which does not assist in answering the research question	Academic research
Dates prior to 2013	Reports
Papers and articles where full access is not granted	Academic books and book chapters
Unverified publications	Case studies
Magazines and newspapers	Library academic literature
Electronic databases	
Ask.com	IEEE
About.com	Wiley Online Library
Encarta.msn.com	Engineering Village
Infoplease.com	ProQuest
Answers.com	Springer
Wikipedia.com	Emerald
	SAGE
	UJ Thesis and Dissertation
	Science Direct

2.3 Study selection, extraction and appraisal

The Prisma chart was used to assist with the implementation of the systematic literature review processes. The extraction of the studies in the database was conducted using the key phrases stated in Table 1. The critique and appraisal method used in the research was based on the Critical Appraisal Skills Program (CASP) [18]. CASP asks questions to all research attained to validate and critique each one. The first three questions are screening questions relating to the relevance of the rigour, significance and reliability of the work. When the study does not get a "yes" to each question, the source will be excluded from the study. The three questions are the following:

1. **Rigour**: "Has a thorough and appropriate approach been applied to key research methods in the study?"
2. **Reliability**: "Are the findings well-presented and meaningful?"
3. **Significance**: "Are the findings useful for my research?"

A further ten questions are subsequently asked to evaluate the relevance of the content to the study. For the study to be used, it is recommended that the pass value should be around "7" or "8" and not lower than "5" but

it is left to the researcher's digression. Each study will be evaluated and rated as shown below with three possible answers [18]: "YES" (1), "Not well defined" (x) or Partially defined" (P).
The ten questions are the following:

1. "Was there a clear statement of the aims?"
2. "Is the research methodology appropriate?"
3. "Was the research design appropriate to address the aims of the research?"
4. "Was the recruitment (data selection) strategy appropriate to the aims of the research?"
5. "Was the data collected in a way that addressed the research issue?"
6. "Has the relationship between researcher and participants been adequately considered?"
7. "Have ethical issues have been taken into consideration?"
8. "Was the data analysis sufficiently rigorous?"
9. "Is there a clear statement of the findings?"
10. "Is this article valuable to my study?"

2.4 Interpreting and Synthesizing

This final stage of the research requires synthesizing using the qualitative research synthesis methods to interpret and combine all the findings. The thematic analysis method is used to code and theme the studies to derive and conclude the findings from the studies.

3. Screening and literature identification

Utilising the methodology discussed in Section 2, the selection of applicable material is shown in Figure 5.

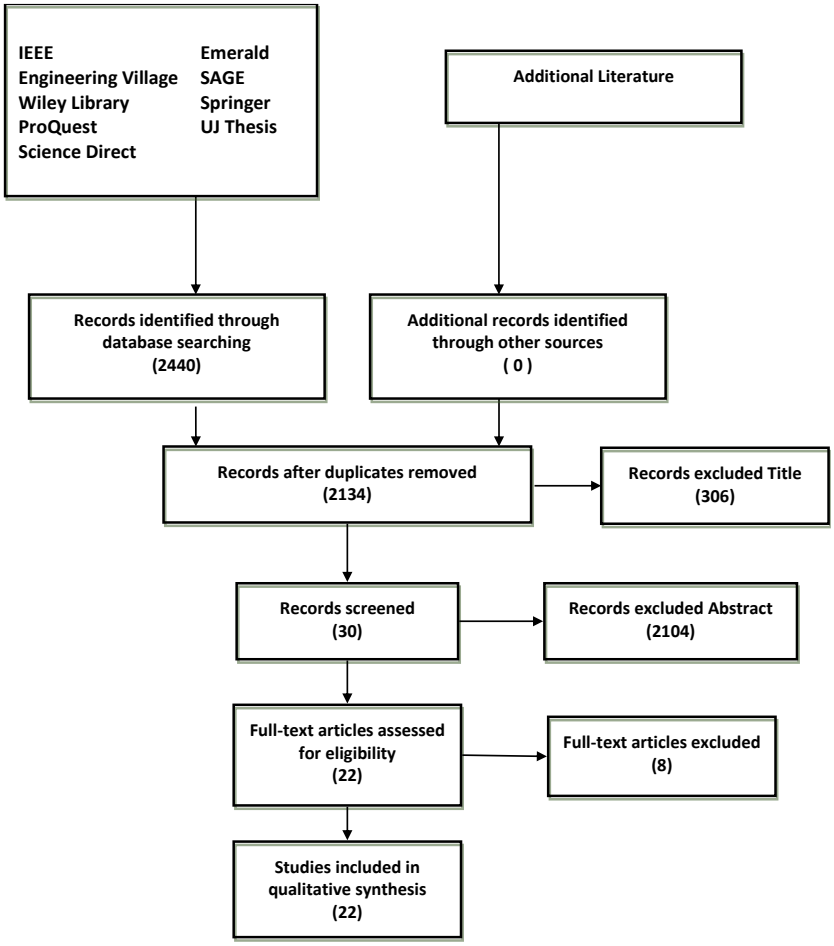

Figure 5: Study Selection Results using Prisma Chart

It can be seen from the figure 5 that after the utilisation of the key search words and phrases in Table 1, a total of 2440 studies were obtained from all the chosen databases as indicated in Table 2. After the removal of all duplicates, a total of 2134 studies remained. These remaining studies were screened by relevance only on their titles, where after a total of 2104 studies were removed. The remaining 30 studies were evaluated on their abstract, guided by the keywords and search phrases in Table 1. The 30 elected studies are summarised in Table 3.

Table 3: Thirty Elected studies

Study ID	Reference
S1	F. Han, "DEFINING AND EVALUATING AGILE CONSTRUCTION MANAGEMENT FOR REDUCING TIME DELAYS IN CONSTRUCTION," 2013.
S2	C. Quiroga and J. Anspach, "Managing Utilities in 3D Design and Construction Workflow," Pipelines 2016, pp. 913–921.
S3	L. R. Ptschelinzew et al., "Best practices in design process development for accelerated construction project delivery," in 7th Int. Structural Engineering and Construction Conf., Research Publishing, Singapore, 2013.
S4	J. K. Larsen, G. Q. Shen, S. M. Lindhard, and T. D. Brunoe, "Factors affecting schedule delay, cost overrun, and quality level in public construction projects," Journal of management in engineering, vol. 32, no. 1, p. 04015032, 2015.
S5	Y. Rosenfeld, "Root-cause analysis of construction-cost overruns," Journal of Construction Engineering and Management, vol. 140, no. 1, p. 04013039, 2013.
S6	I. H. M. Yusof, M. An, and M. H. Barghi, "INTEGRATION OF LEAN CONSTRUCTION CONSIDERATIONS INTO DESIGN PROCESS OF CONSTRUCTION PROJECTS," Management, vol. 885, p. 894.
S7	D. Do, C. Chen, G. Ballard, and I. Tommelein, "Target Value Design as a method for controlling project cost overruns," INTERNATIONAL GROUP FOR LEAN CONSTRUCTION, vol. 22, 2014.
S8	S. T. Demir and P. Theis, "Agile design management -The application of scrum in the design phase of construction projects," in IGLC 2016 - 24th Annual Conference of the International Group for Lean Construction, United states, 2016, pp. 13–22.
S9	J. Mevada and G. Devkar, "Analysis of reasons for cost and time overrun in Indian megaprojects," in MATEC Web of Conferences, Sharjah, United arab emirates, 2017, vol. 120, p. American Concrete Institute;
S10	N.-J. Yau and C.-H. Sun, "Performance evaluation for engineering consultants of MRT projects in design phase," Journal of the Chinese Institute of Engineers, vol. 38, no. 6, pp. 791–800, Aug. 2015.
S11	S. Han, P. Love, and F. Peña-Mora, "A system dynamics model for assessing the impacts of design errors in construction projects," Mathematical and Computer Modelling, vol. 57, no. 9, pp. 2044–2053, May 2013.
S12	J. Yap, H. Abdul-Rahman, and W. Chen, "Impacts Of Design Changes on Construction Project Performance: Insights From A Literature Review," 2015.
S13	M. Li and J. Yang, "Critical factors for waste management in office building retrofit projects in Australia," Resources, Conservation and Recycling, vol. 93, no. Supplement C, pp. 85–98, Dec. 2014.
S14	N. Udawatta, J. Zuo, K. Chiveralls, and G. Zillante, "Improving waste management in construction projects: An Australian study," Resources, Conservation and Recycling, vol. 101, no. Supplement C, pp. 73–83, Aug. 2015.
S15	M. Mukuka, C. Aigbavboa, and W. Thwala, "Understanding Construction Projects' Schedule Overruns in South Africa," in ICCREM 2015, pp. 591–602
S16	A. A. Ezzat, "Challenges of mega construction projects in developing countries," Organization, Technology & Management in Construction; Zagreb, vol. 5, no. 1, p. n/a, Jun. 2013.
S17	I. Mahamid and N. Dmaidi, "Risks Leading to Cost Overrun in Building Construction from Consultants' Perspective," Organization, Technology & Management in Construction; Zagreb, vol. 5, no. 2, p. n/a, Dec. 2013.
S18	A. O. John and D. E. Itodo, "Professionals' views of material wastage on construction sites and cost overruns," Organization, Technology & Management in Construction; Zagreb, vol. 5, no. 1, p. n/a, Jun. 2013.
S19	A. Shafaat, H. Ebrahiminejad, F. Marbouti, M. Cardella, and A. Kandil, "Developing a systematic framework to enhance construction procedure design," in 2016 IEEE Frontiers in Education Conference (FIE), 2016, pp. 1–3.
S20	S. Kärnä and J.-M. Junnonen, "Designers' performance evaluation in construction projects," Eng, Const and Arch Man, vol. 24, no. 1, pp. 154–169, Jan. 2017.
S21	Ajayi, Saheed O.; Oyedele, Lukumon O.; Kadiri, Kabir O.; Akinade, Olugbenga O.; Bilal, Muhammad; Owolabi, Hakeem A.; Alaka, Hafiz A.
S22	A. Sawhney, R. Agnihotri, and V. K. Paul, "Grand challenges for the Indian construction industry," Built Env Proj and Ass Man, vol. 4, no. 4, pp. 317–334, Sep. 2014.
S23	W. Santos, "Towards a Better Understanding of Simplicity in Agile Software Development Projects," in Proceedings of the 20th International Conference on Evaluation and Assessment in Software Engineering, New York, NY, USA, 2016, p. 2:1–2:4.
S24	F. Raith, I. Richter, and R. Lindermeier, "How Project-management-tools are used in Agile Practice: Benefits, Drawbacks and Potentials," 2017, pp. 30–39.
S25	D. Turk, R. France, and B. Rumpe, "Limitations of Agile Software Processes," arXiv:1409.6600 [cs], Sep. 2014
S26	P. Abrahamsson, O. Salo, J. Ronkainen, and J. Warsta, "Agile software development methods: Review and analysis," 2017.
S27	A. Stare, "Agile project management in product development projects," Procedia-Social and Behavioral Sciences, vol. 119, pp. 295–304, 2014.
S28	B. Winter, "Agile Performance Improvement," in Agile Performance Improvement, Apress, Berkeley, CA, 2015, pp. 149–171.
S29	R. Raj, "A Case Study on Enterprise Content Management using Agile Methodology," 2016.
S30	R. Hoda and L. K. Murugesan, "Multi-level agile project management challenges: A self-organizing team perspective," Journal of Systems and Software, vol. 117, pp. 245–257, 2016.

A full-text analysis relating to the eligibility and quality was performed on the 30 articles listed in Table 3. The questions listed in Section 2.3 were asked and the answers are summarised in Table 4

Table 4: Quality assessment answers

ID	First Three Screening Questions				Ten evaluation questions										
	Q1	Q2	Q3	T	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	T
S1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	10
S2	1	1	1	3	1	1	P	P	1	1	1	1	1	1	8
S3	1	1	1	3	1	1	P	1	1	P	P	1	1	1	7
S4	1	1	1	3	1	1	P	1	1	1	1	1	1	1	9
S5	1	1	1	3	1	1	1	1	1	1	P	1	1	P	8
S6	1	1	1	3	1	P	1	X	1	1	1	P	1	1	7
S7	1	1	X	2	P	1	P	X	1	1	1	1	1	1	7
S8	1	1	1	3	1	1	P	P	1	1	P	1	1	P	6
S9	1	1	X	2	1	1	X	1	P	1	P	1	P	1	6
S10	1	1	1	2	P	1	X	1	1	1	1	1	1	P	7
S11	1	1	X	2	X	P	1	1	1	P	1	1	P	1	6
S12	1	1	1	3	1	1	1	1	1	1	P	1	1	P	8
S13	1	1	1	3	1	1	P	1	1	1	P	P	1	1	7
S14	1	1	1	3	1	1	1	1	X	P	1	1	1	P	8
S15	1	1	1	3	1	1	P	1	1	1	P	1	1	1	8
S16	1	1	1	3	1	1	1	1	1	1	1	1	1	1	10
S17	1	1	X	2	1	1	P	P	1	1	1	1	1	1	8
S18	1	1	1	3	1	1	1	1	X	P	P	1	1	1	8
S19	1	1	X	2	1	1	P	1	X	P	1	1	P	1	6
S20	1	1	1	3	1	1	1	P	1	1	P	P	1	1	7
S21	1	1	X	2	1	1	1	1	P	1	1	1	1	1	9
S22	1	1	x	2	1	1	1	P	1	1	P	1	1	1	8
S23	1	1	1	3	1	1	1	1	1	1	1	P	1	1	9
S24	1	1	1	3	1	1	1	1	1	1	P	1	1	1	9
S25	1	1	1	3	1	1	1	1	1	1	1	P	1	1	9
S26	1	1	1	3	1	1	1	1	1	1	P	1	1	1	9
S27	1	1	1	3	1	1	1	1	1	1	P	P	1	1	8
S28	1	1	1	3	1	1	1	1	1	1	1	P	1	1	9
S29	1	1	1	3	1	1	1	1	P	1	1	P	1	1	8
S30	1	1	1	3	1	1	1	1	1	1	P	1	1	1	9

From the answers obtained, 8 studies were discarded, leaving a total of a final 22 studies used for analysing and synthesis. Each of the studies was taken through the Critical Appraisal Skills Program (CASP) [18]. The study of the 22 papers was utilised to identify the challenges in the design phase of civil engineering projects and the possibility of mitigation methods which agile methodologies can offer. The identification of these challenges and the mitigation methods are discussed in the subsequent section.

4. Analysis

Thematic analysis, which is used for qualitative research which utilizes codes and themes, was used in this study. The process is followed by the six steps in which the coding of the data is done [19], [20]. Formulation of thematic analysis using the terms code and theme interchangeably while referring to a specific pattern found in the literature in which one is interested in [21]. The 4 steps are Understanding the Data, Coding, Creating Themes, and Review of themes.

4.1 Understanding the data

This first stage deals with a reading of the 22 studies selected in Section 3. The reading of the studies will help identify patterns and common ideas within the studies. This will assist in coding and theme creation. Which will aid in the attempt to understand the studies by grouping them by literature type.

4.2 Coding

Regularly, the researcher will code lines of content that recognize catchphrases, ideas, pictures and reflections [22]. Coding is a direct and iterative process in which a person will change and alter the investigation as reflected by the information and as thoughts develop. Coding abilities, enhance with more practice [23]. Coding is a clear procedure once the suitable patterns of information have been gathered, and it is at the thesis stage where software packages are most advantageous, as they allow the capacity of a lot of coded information [24]. The way toward coding requires the use of the application of the categories of the data. Normally, all information ought to be coded systematically [23]. Software's have the favourable position that a similar group of words can be effortlessly coded with more than one categorisation [25]. Descriptive coding was used in all the studies, which means that one or two to three words summarise the primary topic of the study within the two categories which are challenges and mitigations as shown in Table 5.

Table 5: Challenges and mitigation strategies identified

Study ID	Challenges	Agile mitigation method applied
S1	Rework, cost & Schedule overrun	Agile theories
S2	Inefficiencies in the design	3D Design
S3	Contracts	Design-build Contracts
S4	Cost & Schedule overrun	Preplanning in the Design phase
S5	Cost & Schedule overrun	Root Case Analysis
S6	Cost, Schedule & Rework overrun	lean thinking
S8	Dynamic & complex environment	Agile Design Management
S12	Design changes	loop model of design changes
S13	Construction waste	Identify critical factors for waste management in office buildings
S14	Construction waste	waste management
S15	Schedule overrun	Identifying Causes
S16	Delivery of Mega Construction projects	Applying Educational strategies
S18	Cost & Schedule overrun	building materials management
S20	Design performance	customer focused or oriented methods
S23	Project complications	Agile Software Development
S24	Project management	Enhances the application of agile methodologies
S25	Limitation of Agile	Hybrid Method Agile and Waterfall
S26	Traditional plan-driven software development methods	Agile software development methods
S27	Uncertain future of Agile	More studies in Agile applications
S28	Performance improvement	Agile methodology
S29	Controlling the increasing content burden	Agile methodology
S30	Project management challenges	Agile Teams

4.3 Creating Themes: challenges and mitigation

The theme is utilized as quality, descriptor, component, an idea. As a verifiable theme that arranges a group of repeating thoughts, it enables researchers to answer the investigation question. It contains codes that have a typical perspective and has a high level of all-inclusive statement that brings together thoughts with respect to the subject of inquiry [24]. Each theme may have some subthemes as subdivisions to acquire a thorough perspective of information and reveals a pattern in the account of codes [24].

The theme is a phrase or sentence describing a more indirect and implicit process [23]. Four main themes were identified in this study related to the challenges faced in the design phase of a civil engineering project. Similarly, the mitigation is categorised into themes with supporting codes. The themes identified from the studies are listed below in the Figure below. It can be seen that the challenges are not specifically contained in the design phase of the project, but can be in multiple phases of the project phase [23].

Table 6: Main themes on challenges and mitigation

Themes	No Codes
CHALLENGES THEMES	
Schedule and Cost Overrun	6
Construction waste	2
Design Performance	3
Project management	6
MITIGATION THEMES	
Agile approaches	12
Model design	2
Identification of causes	2
Management	2

4.4 Review Themes

This stage deals with validating the themes and to investigate if the themes are adequate by applying the dual criteria in judging categories, by evaluating the themes internal homogeneity and external heterogeneity [26], [27]. The review of themes will assist in the refinement of the themes if needed [26].

Internal homogeneity assesses the inside consistency of the information and whether there is sufficient supporting information and whether it is significant. The sample measure is 22 studies and it is adequate for a theme to have 2 principle codes and not less which identifies with the research question. The list in Figure 7 shows the number of codes in each theme [24]. External Heterogeneity evaluates the external heterogeneity of the themes which entails reviewing themes uniqueness and absence of overlaps of similar ideas between the

themes. The themes can relate to each other however one needs to be able to differentiate between them. Two steps were followed to ensure this process is carried through the current themes [19]: Step one was to revisit the extracted codes that make up the theme and see whether there is a consistent pattern [19]. The second step required the determination if the chosen theme is found to be consistent and the codes supporting the theme form a coherent pattern before moving to the next stage. If not, then one has to relook at the themes and maybe change or remove according to the data [19].

5. Discussion

Table 7 summarises the challenges as well as the mitigation strategies found within the identified literature.

Table 7: Summary of results

CHALLENGES	MAIN CAUSES	RESPONSES FROM LITERATURE	AGILE STATEMENTS
Cost and Schedule Overrun	Design Change	Responding to change over after a plan, the ability to be more adaptable to any circumstances is what helps the client to be more in control of shaping the final product instead of allowing circumstances to dictate the final product.	"Responding to change over after a plan" One of agile's four core values.
	Complex projects	Agile ability to take any complex situation and break it down into manageable increments. Including its iterative nature when using the Scrum method is very suitable for unpacking complexity.	
	Client Scope Change		
Waste Management	Quality control	In agile methodology, because of its iterative cycles of continuous learning and development, mistakes are easily picked up and all the errors rectified.	"At regular intervals, the team reflects on how to become more effective then tunes and adjusts its behaviour accordingly. "One of agile's Principles.
	Unclear goals	Agile methodologies can operate under unclear goals and strategies and can help the client reach towards making clearer goals by means of alliteration and innovation	
	Project coordination	It is a cross-functional group of people who constantly interact. The Agile methodology works in cycles of delivering a product every week to the client and during the week by conducting stand up meetings which are generally a fast useful and efficient way of checking progress.	
Design Performance	Problem Solving	Agile methodologies are structured in solving problems by removing bureaucracy as stated in the Manifesto.	"Continuous attention to technical excellence and good design enhances agility." One of the agile's Principles.
	Lack of skills	Agile teams are a cross-functional group of individuals and everyone is important in producing the final product, the team is motivated and skilled and there is no redundancy within the team it is fully functional.	
Project management	Rigid	Agile methodologies, in particular, the Scrum method does not refer to project managers, but rather, Scrum Master, the two roles can be significantly different in some cases, the scrum master is a motivator and a mentor and not viewed as the boss of the team.	"Working programming over exhaustive documentation" One of Agile's four core values.
	Lack of effective communication	Feedback is done more regularly daily stand-up meetings and after weekly sprints, Agile methodologies can offer constant feedback between the teams	
	Documentation intensive	An agile methodology allows for project managers and design team to adapt to changing circumstances, instead of forcing rigid and linear control as in the traditional method	

As indicated by Han (S1), the design change is inescapable in most civil construction projects; these are basically unanticipated difficulties. The customer is the principal instigator of design changes because of vague initial requirements and specifications and in some cases, it is because of financial and political reasons (S1, S4, S5, and S6). As indicated by Li and Yang (S13), Construction waste management is not uncommon, particularly if the project has an implausible course of events and is lacking in budget planning. The waste turns out to be more common when quality is not the principal driver of the design, as a rule, typically cost and time has more weight on the design. As per Quiroga and Anspach (S2), traditional strategies are intended for taking care of issues and improving the design and execution; be that as it may, the linear and hierarchy structure setup can be

an obstruction and might impede viably performing teams (S14). As per Ezzat (S16), a project manager is liked to be a jack of all trades over a specialist in their profession, yet one must have a strong specialized learning (S30). The project manager should know enough to comprehend what is occurring in an abnormal state. A performing manager is consequently, in the design stage, required to incorporate the diverse disciplines that are associated with a project (S24).

Agile methodologies are versatile in nature; they were made at the most for the ever-rapid evolving world. With innovation rapidly changing and the projects ending up more perplexing, it is one of the Agile Methodologies crucial requirements to be more adaptable and to be less entangled and create faster outcomes, and thus the name "agile" (S1). As indicated by Han (S1), the agile techniques can work under uncertain objectives and methodologies and can enable the customer to reach towards making clearer objectives (S1). Its capacity to be more versatile to any conditions causes the client to be more responsible for moulding the results of the project, as opposed to enabling conditions to manage the outcomes of the project (S1). An agile approach takes into consideration project managers and design teams need to adjust to evolving conditions, rather than compelling unbending and straight control as in the conventional method (S28). An ever-increasing number of projects today are led in more eccentric environments as the manager tries to adjust to evolving innovation, industry and market. How the manager manages the project must change to be better arranged and prepared for these kinds of environments (S30). The agile system has a procedure for enhancing the learning of the project circumstance by coordinating efforts with every significant partner (S1).

6. Conclusion

The civil construction industry is an imperative industry in the economy of a developing nation because civil construction projects are the principal drivers of expanding infrastructure and helps with enhancing social environments for the general population. As said that infrastructure contributes on a very basic level toward the South African financial improvement; creating work both directly and indirectly and improves individuals' personal satisfaction through the arrangement of essential financial infrastructure buildings. In any case, this is tended with infrastructure projects pausing and losing a measure of money because of cost and schedule overrun. The design stage was distinguished as the stage at which the greater part of the cost and schedule overrun begins, it was along these lines with reason that it is the stage at which mitigation measures can be connected. Systematic literature review gathers existing information from an extensive variety of sources and tries to deplete the accessible information to find un-bias conclusions.

The main limitation of the systematic literature review is the inclination in the selection of the publication and mistake in data extraction. However, to guarantee that the procedure of selection was unbiased, the research adopted a research protocol in advance that defined the research questions. Utilizing the questions as a premise, search terms and identified catchphrases and key terms that would be relevant in the literature. It is important to note that the search terms were not standardised due to the uniqueness of each electronic database. Therefore, as much as the research has endeavoured with the best capabilities to combine the search phrases to extract relevant studies, there is a risk of omitting some publications due to the key terms were chosen by the research.

To conclude the execution of agile methodology in the design period of construction projects can enhance this stage by limiting the weakness or vulnerability and help in managing the unanticipated risks and having the capacity to adjust to evolving conditions. It can enable structure and aid with the design stage by expanding transparency and enhancing the project, using time management and expanding both the customer's commitment and the camaraderie's.

References

[1] N. Al-Hazim, Z. A. Salem, and H. Ahmad, "Delay and Cost Overrun in Infrastructure Projects in Jordan," *Procedia Engineering*, vol. 182, no. Supplement C, pp. 18–24, Jan. 2017.
[2] M. J. Mukuka, "Cost and schedule overruns on construction projects in South Africa," 2015.
[3] P. Gordhan, "Budget Speech South Africa," National Treasury, Pretoria, South Africa, 2017.
[4] L. J. Khabisi, "Causes and effects of cost overruns in public sector construction projects in South Africa," 2013.
[5] I. PMBOK 5TH EDITION Project Management, *A guide to the project management body of knowledge (PMBOK® guide).*, Fifth edition. Newtown Square, Pennsylvania: Project Management Institute, 2013.
[6] P. Gyorgy and I. S. Fogarasi, "Lifecycle risk management methods for controlling risk factors of underground infrastructure and tunneling projects," in *Underground - The Way to the Future: Proceedings of the World Tunnel Congress, WTC 2013*, Geneva, Switzerland, 2013, pp. 99–103.
[7] M. Y. Johansson, "Agile project management_in construction industry - An inquiry of the opportunities in construction projects," Master of Science Thesis, School of Architecture and the Built Environment, 2012.
[8] P. F. Harris and P. R. McCaffer, *Modern Construction Management*. John Wiley & Sons, 2013.
[9] M. Lentsoane, "Factors contributing significantly to deviations from the initial estimated budgets of construction projects: coal-fired power station projects in South Africa," PhD Thesis, University of Johannesburg, 2016.
[10] I. J. Suleiman, V. G. M. Luvara, I. J. Suleiman, and V. G. M. Luvara, "Factors Influencing Change of Design of Building Projects during Construction Stage in Dar-es- Salaam Tanzania," *International Journal of Construction Engineering and Management*, vol. 5, no. 4, pp. 93–101, 2016.
[11] J. Li, V. W. Y. Tam, J. Zuo, and J. Zhu, "Designers' attitude and behaviour towards construction waste minimization by design: A study in Shenzhen, China," *Resources, Conservation and Recycling*, vol. 105, no. Part A, pp. 29–35, Dec. 2015.
[12] M. Beedle *et al.*, "Manifesto for Agile Software Development," 2001. [Online]. Available: http://agilemanifesto.org/.
[13] M. A. G. Darrin and W. S. Devereux, "The Agile Manifesto, design thinking and systems engineering," in *2017 Annual IEEE International Systems Conference (SysCon)*, 2017, pp. 1–5.
[14] M. Niazi, "Do Systematic Literature Reviews Outperform Informal Literature Reviews in the Software Engineering Domain? An Initial Case Study," *Arab J Sci Eng*, vol. 40, no. 3, pp. 845–855, Mar. 2015.
[15] J. P. T. Higgins and S. Green, *Cochrane Handbook for Systematic Reviews of Interventions*. John Wiley & Sons, 2011.
[16] NIH Library, "Systematic Review Protocols and Protocol Registries | NIH Library," 21-Jan-2014. [Online]. Available: http://nihlibrary.campusguides.com/ld.php?content_id=1380821. [Accessed: 07-Nov-2017].
[17] J. Noyes *et al.*, "Qualitative Research and Cochrane Reviews," 2015.
[18] T. Horsley, C. Hyde, N. Santesso, J. Parkes, R. Milne, and R. Stewart, "Teaching critical appraisal skills in healthcare settings," in *Cochrane Database of Systematic Reviews*, The Cochrane Collaboration, Ed. Chichester, UK: John Wiley & Sons, Ltd, 2011.
[19] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101, Jan. 2006.
[20] D. F. Marks and L. Yardley, *Research Methods for Clinical and Health Psychology*. SAGE, 2004.
[21] U. Flick, *The SAGE handbook of qualitative data analysis*. Sage, 2013.
[22] A. J. Onwuegbuzie, R. K. Frels, and E. Hwang, "Mapping Saldana's Coding Methods onto the Literature Review Process," *Journal of Educational Issues*, vol. 2, no. 1, pp. 130–150, 2016.
[23] V. Clarke and V. Braun, "Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning," *The psychologist*, vol. 26, no. 2, pp. 120–123, 2013.
[24] V. Braun and V. Clarke, "What can 'thematic analysis' offer health and wellbeing researchers?," *International journal of qualitative studies on health and well-being*, vol. 9, 2014.
[25] M. Javadi and K. Zarea, "Understanding Thematic Analysis and its Pitfall," *Journal of Client Care*, vol. 1, no. 1, 2016.
[26] M. Q. Patton, *Qualitative Research & Evaluation Methods*, 3rd ed. Sage Publications, Inc, 2001.
[27] M. Javadi and K. Zarea, "Understanding Thematic Analysis and its Pitfall," *Journal of Client Care*, vol. 1, no. 1, pp. 33–39, Mar. 2016.

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