Academic-Staff Rating Index (ARI) System

by

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ABSTRACT

Supervising students at a distance presents numerous social, mental, professional, and individual challenges on the student- supervisor relationship, and on the substance, progress, and conveyance. From the literature review, several tools and technologies are developed to improve academic quality; however, most of these tools and technologies focus on journal articles' quality rather than student/supervisor relationships. This study aims to develop an academic rating index (ARI) that will show a supervisor's review by students and provide an interactive forum. The application will serve as an academic supervision teaching-level index that provides an aggregated measure of supervisors' past and current impact. Thus, the ARI aims to aggregate all academic supervisor ratings and the number of ratings that they received in the entire academic career to complement their citation index. The study will use quantitative coding and programming tools to ensure a good quality system in the development phase. The application and findings of the study contribute to academic service quality.

KEY TERMS:

h-index; i10-Index; 7Cs Framework; Citation Index; Algorithm; Academic Service Quality; Wilson Score; Binomial Proportion Confidence Interval

DECLARATION

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Academic-Staff Rating Index (ARI)

I declare that this dissertation is my work and the sources that I have quoted have been indicated and acknowledged using complete references. I further declare that I submitted the dissertation to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at the University of South Africa (Unisa) for another qualification or at any other higher education institution.

Recoverable Signature

X 

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“All things were made and came into existence through Him; and without Him not even one thing was made that has come into being. In Him was life [and the power to bestow life], and the life was the light of men.” John 1:3-4

First, I give praise and glory to the author of the universe, be glorified. Hallelujah, glory to the Lamb.

I would like to extend my deepest appreciation to Prof. Marcia Mkansi and Mr. Thabo Mogaswa for believing in me and pushing me in the right direction. Moreover, thank you for always challenging me to be a better person and a scholar. You see possibilities in me only a few can see, and you picked me up from the dust. I stand and eat with kings, and for that, I would like to appreciate you from the depth of my being. I would also like to thank Prof Ernest Mnkandla for his reviews on the work, which has been of great help and excellent guidance. I appreciate the opportunity and the kindness you have shown to me.

Lastly, I want to express my love and affection to my mother, who continuously prays for me. I can attest that it is by her prayers and support that one has managed to reach here. Your words of prophecy that you have sowed in our lives are coming to pass. You have spoken life over us over the years, and your words shall not return unto you void.

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ABBREVIATIONS

- **ARI** : Academic Rating Index
- **CRUD** : Create, Read, Update and Delete
- **H-index** : Hirsch-Index
- **IF** : Impact factor
- **JIF** : Journal impact factor
- **RQI** : Research Quality Instruments/Index
- **7Cs** : 7Cs Framework
- **ICS7Cs** : Interactive Case Scenarios 7Cs Framework

1 CHAPTER 1: INTRODUCTION

This chapter provides an insight into the general perspective on the importance of academic supervision and service quality. Furthermore, it provides a general view of the various service quality methods and benefits/dimensions to improve the service level.

1.1 Context of the Research

This study develops an academic staff rating index system as an indicator of academic service quality. Several scholars define service quality differently but it commonly refers to how well a delivered service conforms to the client's expectations, or the difference between customer expectations of service and the perceived service (Parasuraman *et al.*, 2015, cited in Shahin, 2017; Gronroos, 1984; Crosby, 1979). In academia, service quality includes the student/lecturer interface (Lee and Bacchetti, 2002; Bitzer, 2011; Emilsson & Johnsson, 2007), journal quality (Saha *et al.*, 2003; Bertoli-Barsotti & Lando, 2017), and quality of study material (Zabidi *et al.*, 2017; Series, 2000). The extreme reason for supervision, whether expressed or suggested, is to move forward and enhance the client experience (Kilminster & Jolly, 2000).

The inherent problem in academic service quality lies in supervision (see Table 1.1) . Nassir and Mafakheri (2015) identify academic services quality issues such as timeliness, misinterpretations, and varied feedback as some of the looming problems. Doyle et al. (2017) raise concerns of power and language in supervisory relationships. Andrew (2012) mentions spatial and temporal distance and connection between supervisor and student as some issues. Sussex (2008) links problems of quality and quantity of students' research outcome and experience to supervisors' competency and supervision quality. Nasiri and Mafakheri (2015) recognised few studies that have investigated the challenges of postgraduate distance learning and supervision and have come to a conclusion that there are gaps within the writing concerning creating suitable and successful techniques to address these challenges (Bireda & Asamenew, 2018). The supervisor's role in providing a steady, valuable, and engaged supervision process is vital within the advancement of up and coming practitioners who have the proper guidance and abilities measurements to fulfil the longer-term needs of the discipline (Lee and Bacchetti, 2002).

The aforementioned challenges appear in both remote and face-to-face, but more prevalent in distance learning context. For example, Lessing and Schulze (2002) posit that in South Africa

postgraduate supervision is currently occurring in an era of great transformation, where a great number of students from unpleasant backgrounds are finally getting the opportunity to improve their education by enrolling into institutions of higher learning. Therefore, a huge need for service quality is rising due to the great influx of students. With that, quality is measured by the level to which the expectations of the students can be met on a bespoke level (Lessing & Schulze, 2002). However, supervising students at a distance, presents numerous social, mental, professional, and individual challenges on the student-supervisor relationship, as well as on the content, progress, and conveyance of research activities. While not in close proximity, the supervisor and the student are likely to be preoccupied with other activities and be distracted. With respect to this, research also demonstrates that unlike on-campus students, distance learning students don't have the chance to associate with their peers and mentors frequently for guidance and feedback (Nasiri et al., 2015). Thereby disregarding the shared responsibility in their relationship. As a result, the recurrence and quality of feedback will be compromised (Nasiri *et al.,* 2015; Sussex, 2008).

From a perspective of contact learning, various other problems such as conflict, misunderstanding, misaligning expectations, personality, culture, attitude and having effective interactions have been reported by Ahmadi *et al.* (2020). Selivanova *et al*. (2020) support the latter observation by emphasising that strife is nearly unavoidable in individual and organizational context since it stems from numerous distinctive components. Owing to effects such as the supervisor to student ratio, the supervisor's contribution efforts are segmented into 3 parts: the level of skillset one possesses, the level of support and guidance they offer students, and balancing creativity. Critiques, however, see the supervisor role as a means to advise, ensure scientific quality, and offer passionate help (Lessing and Schulze, 2002). In order to depict the supervisory challenges in the light of a global scale, Table 1.1 demonstrates several studies that have covered the various aspects of the challenges that are found in the supervisor and student relationship. Furthermore, show cases the impact it has either from the campus driven perspective or from a remote or distance-learning perspective.

Technological interest in improving academic service quality exists but focused more on journal quality tools and measurements such as the h-index, ScivVal, and i10-index. These tools and measurements address author-level metrics that measure productivity and quality of research (Une.edu.au, 2019). The h-index, for instance, is a singular value that provides a great bird’s eye-view representation of an authors' citation history and the accomplishments of an author (Bornmann & Daniel, 2019). However, there is no technological solution for

measuring supervision service quality. Yet, a review of literature by previous scholars reveal a range of issues related to academic supervision quality of post-graduates' students from universities to other forms of learning or training environment including high school, training centres, and technical institutions (Nassir & Mafakeri, 2015; Doyle et al., 2017; Andrew, 2012; Sussex, 2008). Nasiri and Mafakheri (2015) identify several studies that have explored the deterrents faced by students in distance learning research supervision and conclude that there is a gap in the literature concerning developing effective and appropriate techniques to tackle these challenges. Hence, this study reviewed academic tools and technologies to help tackle some of these challenges and to contribute to the latter research gap.

Table 1.1. Analysis of the Global challenge context phenomena

Year	**Author**	**Supervision Challenges**	**Mode**	**Global geographical context**			
				Africa	Americas	Oceania	Europe
2019	Munyoka et al.	Student connectedness in open distance learning for Rural Based and Historically Disadvantaged students	Campus Remote	*			
2019	Bireda	Student connectedness in open distance learning: a case of students and supervisors.	Campus Remote	*			
2017	Manyike	Supervision at an open distance e-learning institution.	Remote	*			
2014	Augustsson and Jaldemark	Supervisors strategic communicative influence on student dissertations.	Campus Remote			*	*
2014	Kara	Graduate programs pertaining to good tutor in distance education	Campus	*			
2008	Sussex	Technological options in supervising remote research students	Campus			*	*
2007	Palfreyman and McBride	Learning and teaching across cultures	Campus Remote	*	*	*	*

2006	Harwood and Petrić	Master's Supervision: Perspectives of international students and their supervisors	Campus			*	

1.1.1 Overview of Academic Tools and Technologies for Service Quality

This study reviewed several tools and existing technologies to address academic supervision quality and how they are applied in businesses and other academic standards for rating index. Several literatures, review tools such as the Trivago Rating Index (tRi), widely used in the hotel and accommodation industry, provides an all-inclusive and dependable index of hotel appraisals. The tRI takes accessible rating sources from over the internet and makes use of an algorithm to total them, producing a reliable and fair-minded score (Trivago, 2019).

Another useful tool is the impact factor (IF) of a scholarly publication, it is used as a measure to reflect the average count of citations for the journal that published the papers. This indicator evaluates the relative significance of a journal inside its scientific field. Journals with more prominent IF are regarded as more noteworthy and vital than those with lower bibliographic metrics. The IF was devised by Eugene Garfield, the founder of the Institute for Scientific Information in Philadelphia, to count the scientific journals' impact (Noruzi, 2016).

Another tool is the h-index, a robust tool that is unbiased to an accidental set of modestly referenced or unreferenced papers and one or a few exceedingly referenced papers. To quote the inventor Jorge Hirsch, “A scientist has an index of h if h of his or her Np papers has at least h citations each and the other (Np − h) papers have ≤ h citations each” (Hirsch, 2005). The h-index is appealing because it considers the number of publications and the references for each publication. The h-index considers a body of work that each of its components has at least a certain impact in citations (Shema, 2019). In addition to the h-index is SciVal, making use of the Scopus data. It is a bibliometric tool used to target groups or individuals to analyse their research performance. Researchers can use SciVal to distinguish a publication methodology, discover modern collaborations, and generate assessment reports (WUR, 2019).

SciVal empowers the researcher to assess their study activities as well as compare them to their peers. It enables the researcher to gain a view of a variety of perspectives to assist in the development, execution, and assessment of the procedures based on dependable findings

(Elsevier.com, 2019). Therefore, SciVal enables users to benchmark and analyse publication output at an individual, group, and institutional level. The above tool fosters and influences quality from a behavioural perspective, functioning as a bibliographical tool it fills the need for practical information about citation indicators (Morman, 1981). The judgment formed on the citation impact, may appear to some as biased based on the viewpoint of humanists who in most cases are fundamentally inquisitive about understanding how collaboration cognitive and social structures of science influence the thought process and behavioural aspects of researchers.

The citation index provides a way to handle the process of pioneering and implementing innovative thoughts. Even in its simplest form, the case-study carries an elevated level of interest from a humanistic perspective (Morman, 1981). From the discussion above, several tools and technologies are developed to improve academic quality; however, most of these tools and technologies focus on journal articles' quality rather than student/supervisor relationships. This study extends previous scholars' work by developing a digital complementary supervision measure grounded on theoretical frameworks of measuring service quality as discussed below.

1.1.2 Theoretical Frameworks for Measuring Service Quality

Service quality is a critical point of focus for a successful outcome in that it helps attract and retain business for any institution (Riyan & Saleh, 1991). While the explanations behind the initial visit or keen interest to an establishment might be because of components partly outside the control of the managerial-team, the capacity to make a pleasant experience for the client will rest to an extensive degree inside the hands of both the management and the ground workers (Yang, 1999; Payne & Frow, 2005). In recognising the importance of good-service quality, several models for measuring service quality emerged by selecting and grouping critical elements that were of high importance. The models include SERVQUAL model (Krishna, 2010), 7Cs framework (Anon, 2017), ISO 9126 quality model (Behkamal et al., 2009; Chua & Dyson, 2002), Palmer's model (Sharma & Lijuan, 2015), and Stefani and Xenos quality model (Stefani at el., 2007) as summarised in Table 1.2

Table 1.2. A showcase of the quality factors of the service models

Service Quality Models	Measuring	Quality Dimensions	References
SERVQUAL	Consumer expectations and perceptions	• Reliability • Physical assets • Unwavering quality • Assurance • Sympathy	Parasuraman et al. (1985)
7Cs framework	Aimed towards planning learning measures utilising current learning innovations	• Conceptualise • Capture • Combine • Communicate • Collaborate • Consider • Consolidate	Johnston-wilder and Lee (2010); Buch et al. (2018)
The ISO 9126	Address a portion of the notable human predispositions that can unfavourably influence the service delivery	• Functionality • Reliability • Usability • Efficiency • Maintainability • Portability	ISO (2001); Behkamal et al. (2009)
Palmers	Usability of a subject under scrutiny	• Content quality • Navigation • Responsiveness • Interactivity • Information access delay	Drahansky et al. (2016)
Stefani and Xenos quality	End-user focal attention easy access, adaptation, usefulness, legitimate, correct, and accurate information	• Functionality • Usability • Efficiency • Reliability	Drahansky et al. (2016)

Although the models presented in Table 1.2 commonly focus on measuring service quality, they emphasise different quality criteria. For example, Zeithaml, Parasuraman, and Berry (1985) discovered five measurements' that clients use when assessing service quality: the tangibles, reliability, responsiveness, assurance, and empathy. They then named their survey instrument SERVQUAL, and concluded that getting a minimum of two of the five measurements' can encourage consumers to be loyal to the service provider, according to

what is important to them, the consumer would have received an excellent service (Service performance, 2019). The 7Cs framework measures quality by addressing the criteria of conceptualising, capturing, creating, communicating, collaborating, considering, and consolidating various aspects Buch et al. (2018).

The ISO 9126 standard is centred around five fundamental principles: functionality, reliability, usability, efficiency, maintainability, and portability (ISO, 2001). The early 1970s, and 1980s, saw the initialisation and improvements of the ISO/IEC 9126 standard. The ISO 9126 is classified in the family of the ISO 9000 standard, which is the main quality assurance standard. This model's classification is assembled in a hierarchical structure to display the attributes and sub-attributes of the software product (ISO, 2001).

Palmer's model measures quality based on a subject's usability under scrutiny (Drahansky et al., 2016). This model seeks to focus on the usability of a subject under critical observation or examination. Focusing on the design of the subject areas such as the design standards that covers simplistic user-experience or interaction, periodic updates, low information transferal period, intuitive to users, high-quality content, latency, and reliability (Palmer, 2002).

Stefani and Xenos's measurement of the quality model include conceptualising, capturing, combining, communicating, collaborating, considering, and consolidating the various aspects of the subject under scrutiny. The measurement is built on three levels – high, middle, and low (Drahansky *et al.*, 2016).

Table 1.3. Stefani and Xenos's measurement of quality (Stefani & Xenos, 2001)

Factor Level	Factor Focus
The high-level	The undeniable level contains fundamental attributes of electronic trade frameworks, for example, the web crawler engine, navigational simplicity, security, and reliable transaction processing.
The middle level	The middle level incorporates site map administrations, localisation, and an appealing interface.
The low level	The low level incorporates extra services and facilities focused on the enhancements of user experience and usability, and productivity like strategically pitching a variety of visual-themes, fonts, and icons.

In comparing the different models, the literature review reveals the different focus of each model. For example, ISO9126 is a service quality model designed to evaluate software

products. The standard is mainly awarded to those seeking ISO certification (Djouab & Bari, 2016; Chua & Dyson, 2002). The Stefani and Xenos quality model is designed to assess e-commerce system quality based on ISO9126 Bayesian networks. It serves as a measuring criterion, which can be used to assess the business-to-business electronic-commerce system's performance and reliability (Chengbo *et al*., 2016).

Palmer's model for quality is designed specifically for Interactive media formats to supply the site with visual-depth and richness by providing a single-entry point for multiple pages simultaneously (Sharma & Lijuan, 2015). The SERVQUAL model seeks to capture consumers' actual or perceived gaps between customer expectations and perceptions of the service offered (Shahin, 2017). The 7Cs framework is an exceptional measure of service quality designed specifically for the academic environment (Buch et al., 2018; Johnston & Lee, 2010). The model provides supervisors with the direction and support they require in order to make informed choices that are aligned with newer technologies (Conole, 2016). Supervisors have expressed the thought that activities and resources assist them to think outside of the current scope in order to help improve the experience of the students (Resource, 2009).

While the criteria and framework pave a good foundation for measuring supervision, little is available in digitalising the theory to a global platform that can serve as a central point of reference and transparent measure of quality. This study extends the theoretical frameworks of service quality by developing a digital academic rating index that will aggregate an academic-staff' supervision or teaching experience by different students from different universities. The 7Cs framework emphasises different dimensions of the learning process, hence its consideration as the foundation variable for the ARI, as discussed in-depth in Section 2.4 of this study. The following section discusses the problem statement.

1.2 Problem Statement

An increase and expansion of distance learning and correspondence programs has been seen since the arrival of the internet and digital platforms of communications that have emerged. This has caused the growth and development within the literature that assesses the attributes and challenges faced in remote learning and supervision. In distance learning institutions, student and supervisor face-to-face interaction is minimal and close to none in some instances. The quality output of the interactions may not be as beneficial as expected. The structure and setup of a distance learning program can be a factor for the negligible level of cohesion

between the student and the supervisor. The supervision issues are not limited to distancing learning, but also include contact learning context as observed by Ahmadi *et al.* (2020) and Selivanova *et al*. (2020). The scholars commonly observed issues such as conflict, misunderstanding, misaligning expectations, personality, culture in contact or face to face learning context. These challenges are exacerbated by the lack of a digital global transparent system for students to rate their supervision experience and the associated issues that arise from it. The supervisory role does not have a centralized environment that amalgamates the ratings of a supervisor which can also be used to complement their citation index. Yet, ratings and reviews are the key determinant for invaluable feedback necessary to surface issues and shed intelligence to help manage supervision service quality.

1.3 Research Aim

This study follows on the foundation laid by scholars who measured journals' quality through technological and mathematical advancements such as the IF and the widely used h-index (Hirsch, 2005), Google i10-index (Club, 2019), and its direct descendant, the I20 Index (Noruzi, 2016) and uses a 5-point Likert scale to invoke the algorithm to develop an academic staff-rating index. Specifically, the study provides insights into the student-supervisor relationship aspects.

This study aims to develop an ARI (technological solution in the form of a web and mobile application) to help reflect the student and supervisor relationship's outcome in line with supervision. Thus, the objectives are discussed below.

1.4 Research Objectives

To address the research aim stated above, this section will be addressing the following objectives:

a) Develop an algorithm to measure academic supervision quality, using the Wilson score interval to get a confident estimate about the actions or preferences of students in general towards a supervisor.
b) Compute and standardise the application to be suitable for different learning environments. The 7Cs framework will be used to examine key issues in validating the student's perception of their supervisor.

c) Compile a cross-platform relational database to store the cloud data by using SQL database instance that can be hosted on Azure cloud.

1.5 Research Questions

a) How can the Wilson score interval be optimised into a software algorithm?
b) What level of abstraction will be implemented to ensure that the 7Cs framework can be adapted in different learning/academic environments?
c) How will the database entities be relationally mapped to one another?

1.6 Significance of Study

In theory, this study aims to improve the service quality between student and supervisor to ensure a much richer and more meaningful relationship experience for both parties. This will allow students to know and understand who they are dealing with and what manner of approach is required to get the supervisors best experience. In addition, it will help pinpoint the areas of improvement and dominance in the subject/module at hand from the supervisor's side. Thus, it will help supervisors to render much better service.

In practice, the ARI will also show supervisors, lecturers, and teachers' overall ratings and reviews by students and provide an interactive forum where both parties can engage and share thoughts towards a better academic supervision service quality. The rating scales are useful in gaining insight into the truth behind the data, and indexes are useful in pinpointing certain attributes easily. Institutions, students, and academic-staff can then determine the level of quality each academic-staff provides to their students. The study provides a comprehensive and reliable index for the rating system. The system will consider ratings from students and supervisors from the publicly open application and utilise an algorithmic calculation to sum them, thus providing a reliable, impartial, clear, transparent, current, and fair score.

The system is needed to instil a greater sense of accountability from academic personnel such as lecturers, teachers, and supervisors so that they can provide an excellent service to their clients (students). Therefore, this study builds a community of ratings and reviews where all stakeholders can search and find the prospective academic personnel, view their score, and have an input in their rating. Similar numerous platforms exist in the hotel booking and

reservation sector, one such is booking.com (Booking.com, 2019), a travel fare aggregator website and travel metasearch engine for lodging reservations.

The data collected from the proposed tool will assist all parties involved with the following points:

a) Improved decision making.
b) Proper assigning of supervisors based on strength indicator.
c) Infuse richer accountability from all parties involved.
d) Serve as academic intelligence for recruitment, training, and reflection.
e) Predict future outcomes based on historical data, using artificial-intelligence techniques (as a future project).

1.7 Scope and Limitations of the Study

Owing to the nature of the study, a computer lab-based approach will be used. The pilot of the study with targeted users will be a future project. Although this study can be implemented across all academic institutions, the study has been narrowed by focusing on the University of South Africa. The ratings will assume that all students are enrolled in the current academic period and will not consider historical academic enrolments.

1.7.1 Computational Predictive Limitations:

The ARI algorithm will not at this point predict future behaviour. The algorithm was not developed with machine learning capabilities, but rather in a static input/output manner to perform operations based on the currently available data. The ARI is at this point not designed to tell us about a qualitatively different future from the past.

1.7.2 Technical Limitations:

Due to poor network connectivity or low coverage in some areas, congested traffic, and high data prices, it is not uncommon for users to experience sporadic connectivity issues and slow download speeds on smartphones running on GPRS/EDGE networks (Javed & Siddiqui, 2017). Slow mobile hardware also constitutes a technical limitation. While the performance of touch devices is improving rapidly, there are users who have slow devices compared to faster

and expensive upper market devices (Zheng & Ni, 2006). This may result in the app initialisation and usage being slow.

1.8 Chapter Summary

This chapter has shed light on the study's purpose and what it intends to achieve by uncovering the research problem, objective, and scope of limitation. Briefly, the chapter presented an introduction to lay the foundation for the coming chapters.

2 CHAPTER 2: LITERATURE REVIEW

Earlier in Section 1.1.2, the theoretical frameworks for measuring quality were discussed, and the 7Cs framework was considered suitable for this study due to its academic focus. This section provides the theoretical background of index theory, followed by discussing the different index models. After that, the 7Cs framework as the theoretical subset lens of measuring quality is discussed and considered. Following the theoretical lens of measuring quality is an in-depth review and discussion of indexes behind the existing academic tools and technologies. Subsequently, the chapter will discuss the adaptation of the 7Cs to an algorithm, the level of abstraction thereof, and the conversion into a programmable software. In conclusion, the study presents a conceptual framework for an academic rating system, focusing on supervision.

2.1 Index Theory

The index theory studies a type of an unwavering topological differential operator on a manifold and the local formula of the invariant in terms of the manifold's geometry (Fisman & Zitzewitz, 2018). According to Hochs and Wang (2018), to determine an index and supply index formulas, one has to specify what meaning of index is concurred upon. At that point, one needs to indicate to what classes of administrators these equations will apply, and finally, the author must clarify how to utilise these equations in applications.

Topological studies in mathematics are mainly focused on the attributes of a geometric object that are preserved beneath persistent deformations, such as extending, turning, folding, and bending, but not tearing or sticking (Munkres, 2014; Kuratowski, 2014; Kelley, 2017). While topological areas can be extraordinarily diverse and foreign, many areas of a topology's centre of attention are on a more acquainted area of classification acknowledged as a manifold. A manifold is a topological area that takes after the system of geometry based on the work of Euclid area close to every point (Rosenthal, D, Rosenthal, D, & Rosenthal, P, 2018).

More precisely, each factor of a $\boldsymbol{n-dimensional}$ manifold has a local that is a function of a one-to-one mapping between sets such that both the function and its inverse are continuous and that in topology to the Euclidean, self-evident or unquestionable system area of a $\boldsymbol{dimension-n}$ (Mariano, 2016). Many topological properties have been proposed and

measured to characterise a group or system of interconnected people or things (Pastor-Satorras & Castellano, 2017).

According to Pastor-Satorras and Castellano (2017), the generalised $\boldsymbol{H(n)}$ Hirsch-Index of order n has been as of late presented and appeared to interpolate between the degree and the K-core, centrality in a group or system of interconnected people or things, measuring centrality and pointing at the relative significance of authors highest point within the general topology.

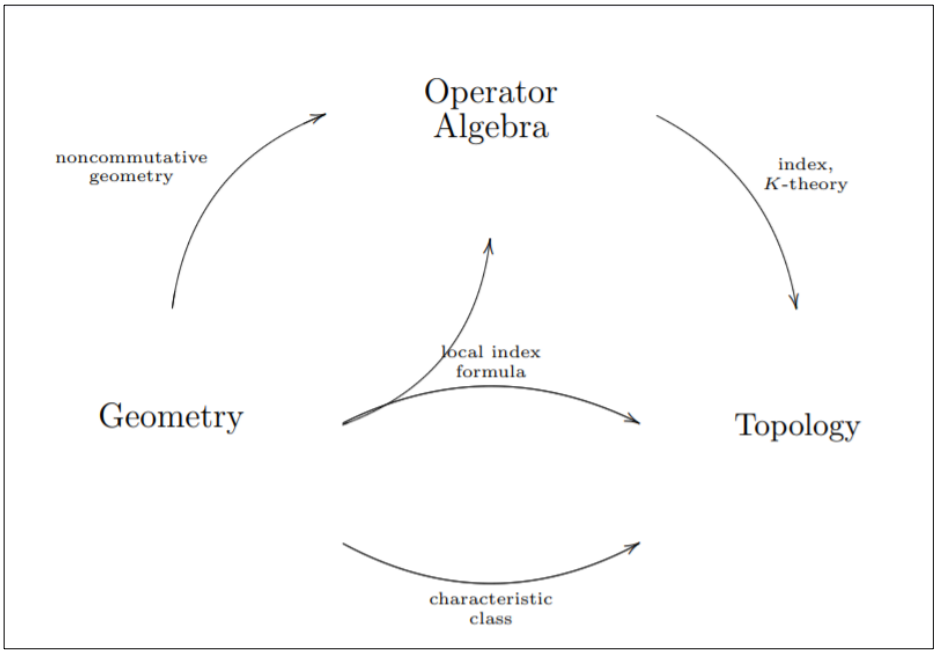


Figure 2.1. Index Theory Relevant Areas (Wang, 2012)

Noncommutative geometry is a branch of arithmetic concerned with a geometric approach to noncommutative algebras and with the development of spaces that are locally displayed by noncommutative algebras of capacities (Connes, 2019). The aim of the k-theory in the proof and programmes of the index theorems can rarely be overstated and does no longer forestall at presenting an interpretation of the index as an element of a k-theory group. Logarithmic k-theory is a topic region in arithmetic with associations to geometry, topology, ring concept, and a wide variety of principles (Connes & Kouneiher, 2019; Karoubi, 2006). Local index formula, a not-so usual function of the first three main index formulation of atiyah–singer and atiyah–segal, relies most effectively on the main symbol of the operator whose index they compute (Atiyah & Singer, 1968; Mills, 2019).

Finally, one of the most critical desires of index theory is to look at programmes of the index theorems to geometry, physics, organisational representations, evaluation, and other fields. There may be a very long and rapid-growing listing of papers coping with those programmes. This study is grounded on index theory and extends on different index models that applied index theory in publication-quality, as discussed below.

2.2 Different Types of Indexes

Several indexes exist in the market. One of them created and maintained by Google as a citations feature, the i10-index, which measures the number of papers with 10 or more citations (Delgado et al., 2014). The i10-index gives the researcher several online-published article citations and citations by other authors with 10 or more references. In the event that in excess of 10 writers have alluded to an article in their research articles, the article shall have a different fundamental value as far as the consistency of the report metrics is concerned (Ahmed et al., 2016). The i10-index is a sole metrics by Google scholar, and it is not part of other well-known publishing institutions. Google Scholar only creates the i10-index and uses it to show quality metrics of the author and gives credit to the author.

Another index is known as the i20-index, which is the newest in the line of journal metrics. Noruzi (2016) defines the i20-index as a simple and easy indexing measure found by counting the total number of articles published in a journal with at least 20 citations, thereby helping editors to change their concerns and motivating journal-publishers to embrace more relevant papers that peers can use and cite. Webology is yet another index, which is indexed by the Scopus database since 2006. The Scopus Journal Metrics allow for direct comparisons between articles, irrespective of their topic classification (Ahmad et al., 2018).

The above-mentioned reviews reveal a polarised view of effective measurement of indexes, thereby prompting the majority of scholars to gravitate towards one of the tools used for assessing the consistency of journal impacts in publishing scientific papers (Greenwood, 2007), this is determined by Thomson Reuters Scientific Division and is published yearly in the Journal Citation Reports. The IF was founded in the 1960s by Eugene Garfield and Irving Sher, who were concerned that merely referring to the number of articles published by a journal in any given year would lose out on small yet significant journals in their Scientific Citation Index (Bornmann & Daniel, 2019). The IF value refers to the average number of times an article that was published in the past 2 years has been cited and is calculated by dividing the number of

citations in the journal-citation report as stated by Bornmann and Daniel (2019). The substantial use of the IF and how it is calculated has faced a lot of criticism and even scepticism (Petsko, 2008). According to Notkins (2008), some critics suggested that it equates incorrectly with the IF of the journal in which it was written. The author also argues that some scholars are more concerned about publishing in high-IF journals and less concerned about their research work, which has a negative effect on the peer-review and academic dissemination process. Simons (2008) states that scholars publish their papers to journals that have a higher IF and try their luck regularly with journals further down the IF ladder when the big players reject them. The editors and critics view it as a waste of time.

However, the Hirsch (h-index) algorithm is gradually replacing the IF to represent the research achievements of an author, which is fascinating to many researchers. However, some authors and researchers have criticised the combination of publications and citation frequencies into one value:

> *"The problem is that Hirsch assumes equality between incommensurable quantities. An author's papers are listed in order of decreasing citations, with paper X having C (X) citations. Hirsch's index is determined by the equality, h = C (h), which posits equality between two quantities with no evident logical connection." (Lehmann et al., 2008)*

According to Bornmann and Daniel (2009), the drastic intake or adoption of the h-index is that it is not being utilised as it were as a measure of logical achievement for individual researchers, but moreover to measure the logical output of research groups, scientific facilities and even countries (van Raan, 2006). In the event that the h-index is utilised for the evaluation of research performance. In that case, it ought to continuously be taken into consideration that, similar to other bibliometric measures, it is dependent on the length of a scholar's career and the field of study in which the papers are published and cited. The h-index is seen to have the advantage in that it provides a robust estimate of the broad impact of a scientist's cumulative research contributions (Hirsch, 2005)

The h-index can be used no longer solely to determine the previous productiveness; it can be additionally used to make out the most currently published study be in a better position than different bibliometric indicators to predict a scholar's future productiveness (Ball, 2007). For this reason, Hirsch (2007) finds the h-index as a useful indicator of scientific quality that can be profitably used (together with other criteria) to assist in academic appointment processes

and to allocate research resources (Bornmann & Daniel, 2007). The h-index's focus is very important because the physiological effect that these ratings can have on human beings can be very impactful since they do not always reflect the most accurate version of the truth. Simply due to the fact that tools like the Google i10-index, Scopus and h-index mechanisms are not immune to reflect artificially inflated bibliometric figures, through the creation of false documents that cite the author (self-citation), and consequently, the journals in which they have published modifying their bibliometric figures. While there are many types of indexes for publication, there are few, if any, on the student-supervisor relationship, hence the purpose of this study. At the centre of each index model are rating scales and algorithms.

2.3 Drivers of Academic Service Quality Tools and Technologies

Indexes are designed to find information quickly and easily. A complete and useful index is an ordered map, with cross references, a grouping of like concepts or other valuable intellectual study. A list of the terms and the phrases that are used for publication (which is commonly referred to as the concordance) is not just a list. The index aims to assist the researcher or general individuals in finding information, so that the indexer is a link between the text/information/data and the end-user or consumer. The underlying methodology behind indexes is rating scales and algorithms grounded in index theory.

2.3.1 Different Types of Rating Scales

The rating scale is the most commonly adopted alternative of the common problem of multiple-choice questions. It is used for collecting data to provide relative information on a particular topic. Researchers use a rating scale to equate a qualitative activity with the different aspects of a product or function (Garland, 1991; Wolins et al., 1983).
Graphical, numerical/mathematical, descriptive, and comparative rating scales are the four most widely known scales easy to understand. They offer a comparative analysis for quantitative data samples and help researchers to make more well-informed decisions (Kotari, 2004; Sekaran & Bougie, 2010).

There are two primary categories of attitude/behaviour/conduct scales: the rating scale, and the ranking scale (Sekaran & Bougie, (2010).

a) Rating scales have a few response categories and are utilised to evoke reactions with respect to the abstract-things, occasion, or individual being studied.
b) On the other hand, ranking scales, make comparisons between objects, occasions, or people and inspire the preferred choices and positioning among them.

Tables 2.1 and 2.2 document the details of the widely used rating and ranking scales and provide an example of the usage of each item.

Table 2.1. Rating Scales that are often used in organisational research

Rating Scales	Description	Example
Dichotomous scale	It is classified as a nominal scale that evokes a yes or no reply (Sekaran & Bougie, 2010; Bhupalam, 2019).	Do you own a car? • Yes • No
Category scale	A nominal scale that uses different things to evoke a single reaction (Sekaran & Bougie, 2010; Dunn-Rankin et al., 2014).	Where in northern California do you reside? • East Bay • Peninsula Other
Semantic-Differential scale	• It comprises of a set of a bipolar rating scale that has 7 focus-point from which the respondent can rate. • Utilised to evaluate one's states of mind toward a specific brand, promotion, or person (Sekaran & Bougie, 2010; Dunn-Rankin, 2014).	Would employ such terms as • Good–Bad • Strong–Weak • Hot–Cold
Numerical scale	It is an interim scale comparative to semantic with bipolar targets of 5 or 7 focuses, it makes use of numbers (Sekaran & Bougie, 2010; Willits, Theodori & Luloff, 2016).	Happy - 5 4 3 2 1 - Unhappy
Itemised rating scale	An interim scale with a 5 or 7 point of focus adjusted (with a unbiased point) or lopsided (without an impartial point), whereby a respondent states or indicates by marking the fitting number on the side of each item under scrutiny; which is afterward summed up together (Sekaran & Bougie, 2010; Prisciandaro & Tolliver, 2016).	• Very Unlikely -1 • Unlikely - 2 • Not Sure - 3 • Likely - 4 • Very Likely - 5
Likert scale	A 5-point anchor scale treated as interval, analysing how strongly subjects concur or opposes the idea with articulations (Sekaran & Bougie,	I would recommend my supervisor to other students • Emphatically disagree

	2010; Willits, Theodori & Luloff, 2016; Russell, 2010).	• Disagree • Maybe
Stapel scale	It is an interval scale that evaluates the course and depth of the demeanour at the same time. Towards the concept under review. The traits of interest with regards to the study are situated at the centre with a numerical scale extending from +3 to -3 of a cartesian plane for the item under review (Sekaran & Bougie, 2010; Russell, 2010).	• + 3 • + 2 • + 1 Adopting Modern • - 3 • - 2 • - 1
Graphic rating scale	A scale that makes use of graphs, charts, or face-emojis in some instances to demonstrate a respondent's sentiments with regard to some perspectives of the phenomena (Sekaran & Bougie, 2010; Lunenburg, 2012).	On a scale of 1 to 5, what rating would you give your teacher on his/her class engagement? • 5 Excellent • 3 Just Okay • 1 Very bad

Table 2.2. Ranking Scales that are often used in organisational research

Comparative Scales	**Description**
Paired Comparison	A scale is utilised to observe and survey inclinations, between 2 parallel objects simultaneously (Sekaran & Bougie, 2010; Dunn-Rankin et al., 2014).
Forced choice	A scale for positioning or ranking objects in connection to others (Sekaran & Bougie, 2010; Brown & Maydeu-Olivares, 2018).
Comparative	A benchmarking scale for evaluating attitudes towards the objects under review in relation to one another (Sekaran & Bougie, 2010; Dunn-Rankin et al., 2014).

The upper hand of ranking scales is that it is less demanding and quicker to implement, however, where items to be ranked are a lot, respondents might just respond for the sake of finishing the questionnaire instead of being truthful and carefully selecting the appropriate answers to provide a more accurate ranking (Kotari, 2004).

The study chose the Likert scale to meet the requirements that this body of research aims to fulfil. It is deemed relevant in achieving the objectives. This study will employ a Likert scale to examine how strongly subjects agree or disagree with statements posed by the application questions pool.

The strength of the Likert scale is in understanding the respondents' sentiments shared towards their mentors. Averin et al. (2017) state that If you have a series of individual questions

that have Likert response options for your participants to reply or you have an arrangement of Likert-type questions that when combined depict a personality attribute or attitude, it is best fitted to employ this mechanism. For a comprehensive and reliable index of academic-staff ratings, the data collected will be processed through data analytics and algorithms to aggregate them to provide a dependable and impartial score that the public in general and the academic institutions can understand. Therefore, supervisors and their institutions will be able to pinpoint areas of improvement for better service delivery. To optimise the rating scales and indexes, different computing theories and algorithms are reviewed and considered in the next section.

2.3.2 Computing Theory

The computation theory is a subset of computer science and mathematics combined to determine how efficiently problems can be solved using algorithms on a computational model. The usage of the theory of computation requires alternating the algorithms so that the study can obtain a more reliable solution. This theory is approached through three main fields (Moldoveanu, 2016; Rescorla, 2015).

Table 2.3. Different branches of the computing theory

Theory Fields	Description
Automata	Mathematicians established this branch in the 20th century. The main aim of this branch is to analyse the behaviour of devices and how they solve a problem (Fatima, 2016; Löding, 2012).
Computability	This branch of the computation theory studies which problems are computationally solvable using different computation models. It is when the computer can address the problem but unable to come up with the solution (Immerman, 2004; Cooper, 2017).
Computational Complexity	The complexity theory discusses the efficiency at which a problem could be solved. This is done considering two major aspects: time complexity and space complexity, which are the measures of the number of steps needed to analyse and solve the problem and thus determining the memory space needed to solve the problem (Bossaerts & Murawski, 2017; Goldreich, 2008).

Based on the characteristics of each branch of the computing theory outlined in Table 2.3, this study aims to make use of the computational complexity theory due to its inherent ability to prove and discuss the efficacy of the problem. Computational complexity helps to identify

problems, often calculated by how long and how much memory it consumes before a problem is solved (Aspnes, 2017).

The complexity theorem comprises multiple models: the deterministic and stochastic models. In deterministic models, the functions performance are completely determined by the parameter values and initial conditions, while stochastic models have some intrinsic unpredictability (Baroni & Tarantola, 2014; Ye & Xie, 2015).

In conclusion, for a given set of inputs, a deterministic process will show the same results, irrespective of how many times one re-calculates it, hence, the reason for consideration in this study. Below is a review of different types of algorithms necessary for the implementation of computational complexity theory.

2.3.3 Different Types of Algorithms

Reinert (2010) shares some thoughts in a synopsis that there are many forms of algorithms, but the most common types of algorithms under the main algorithmic paradigm are dynamic-programming, backtracking, dividing and conquer, greedy, brute-force, randomised and the recursive. He defined an algorithm as a series of autonomous instructions or behaviour representing a finite space or sequence that will lead to a certain problem over a certain amount of time. The fundamental types of the algorithm under the main algorithmic paradigm are covered in Table 2.4.

Table 2.4. A table showing the different types of Algorithms

Algorithm Category	Function
Recursive	Directly settles the base case and afterward repeats with less difficult or simpler info without fail (A base worth is set at the beginning for which the calculation ends) (Reinert, 2010; Bao et al., 2015). • Specifically solves the base cases. • Loops with an easier sub-problem. • Does a few additional works to change over the solution to the easier sub-problem into an arrangement to the given problem
Dynamic programming	A dynamic programming calculation (otherwise called dynamic improvement algorithm) recollects the previous outcome and utilises them to discover new outcome. Implying that it tackles complex issues by separating it into a collection of easier sub-problems (Reinert, 2010; Cormen et al., 2009).

	• Multiple solutions exist; ought to discover the most excellent one. • Requires ideal substructure and covering sub-problem. • Optimal substructure: Ideal solution contains ideal arrangements for sub-problems. • Overlapping sub-problems: Solutions to sub-problems can be put away and reused in a bottom-up design.
Backtracking	A backtracking algorithm is established on a depth-first recursive search (Reinert, 2010; Nagy, 2017). • Tests to see if a solution has been found, and if so, returns it; otherwise If no choices remain, return failure. • For each choice that can be made at this point. - Take the decision - Recursively iterate the records, If the loop returns a solution, return it.
Divide and conquer	The divide and conquer is made up of two components (Reinert, 2010; Gulia et al., 2015; Cormen et al., 2009). • To begin with, it partitions the issues into smaller sub-problems of the same kind and tackles them recursively. • Combine them to create the solution of the initial issue.
Greedy	Greedy algorithm solves the problem by taking optimal solution at the local level (without regards for any consequences) with the hope of finding an optimal solution at the global level (Reinert, 2010; Cormen et al., 2009). • You take the most excellent you'll be able to get right presently, without respect for future results. • You trust that by choosing a local optimum at each step, you may finish up at a global optimum A greedy algorithm is utilised to discover the most-ideal solution, but it is not necessary that you find the optimal solution by following this algorithm.
Brute Force	A brute force algorithm essentially tries all the conceivable outcomes until a satisfactory solution is found (Reinert, 2010; Elman et al., 2015; Li & Amenta, 2015). • **Optimising**: Discover the leading solution. This may require finding all solutions, or on the off chance that value for the leading solution is known, it may halt when any best solution is found. • **Satisficing**: Halt as soon as a sufficient solution is found. It is used to find the optimal (best) solution as it checks all the possible solutions.
Randomised	A randomised algorithm utilises a random number at least once amid the computation to decide (Reinert, 2010; Elman et al., 2015; Motwani & Raghavan, 1996; Martinsson et al., 2019).

	• Randomised algorithms more often than not have the effect of irritating the parameter. On the other hand, the parameter looks arbitrary, which makes terrible cases very rarely. • Randomised algorithms are regularly conceptually very simple to execute. At the same time, they are in run time frequently superior to their deterministic counterparts

For meeting the researcher's objectives, this study aims to implement the dynamic programming algorithm strictly for its memory ability. This way the algorithm enables the study not to report the same problems it faced previously (Chiba, 1978). Dynamic Programming is a way to solve a complex issue by drilling down towards a more simplistic array, addressing each of the sub-problems once and preserving the solutions using a memory-based data structure.

Each sub-problem solution is indexed in a few ways, ordinarily based on its input parameter values, to encourage its lookup. Hence, the next time the same sub-problem happens, rather than recomputing its solution, one essentially looks up the already computed solution, in this manner sparing computation time. This strategy of putting away solutions to sub-problems rather than recomputing them is referred to as memorisation (Medium, 2019; Rivas & Eddy, 1999). The drivers of technological indexes are understood. Of importance to supervision relationship is the measurement of quality of the supervision relationship.

The drivers of academic service indexes and technologies (ranking scales and algorithms) are not viewed in isolation but integrated with the grounding measures of service quality. In other words, while ranking scales and algorithms provide the engines through which index models are achieved within the remit of the index theory, the measurement of academic service quality provides the lens through which ranking, and algorithm are modelled. The next section provides an in-depth discussion of the criteria for measuring academic service quality, central to ARI development. Put simply, in this study, the criteria of measuring quality serve as the lens through which index theory is applied, and rating scale and algorithm of supervision quality can be studied and understood.

2.4 Criteria for Measuring Academic Service Quality: 7Cs Framework

Today's employers and political leaders expect higher education institutions to equip students with the knowledge and skills needed to become competent participants in the 21st-century workforce and knowledge economy (Bundy & Howles, 2017; Mishra, 2013; Shaker, 1999). In academia, the above-mentioned expectations rest upon supervisors' and teachers' shoulders and their ability to bridge theory and practice (Buch et al., 2018).

The emphasis made by the latter scholar is that students' learning path is dependent on the designed teachers' learning path philosophy. Institutional administrators and faculty-teams at postsecondary institutions are searching for innovative approaches to meet these expectations (U.S. Department of Education, 2016). A major part of this challenge resides at the course level, rethinking what students are taught and the instructional approaches used to design and deliver impactful learning experiences (Bundy & Howles, 2017).

In this study, the focus will be laid on the 7Cs framework, which according to Buch et al. (2018) is the most advanced and comprehensive dynamic measure of academic service quality (see Figure 2.2 for illustrative model criteria). The strength of the model extends far beyond measuring quality to incorporating and acknowledging the interactive process necessary for academic service quality, such as the need for a closed-loop feedback mechanism between various stakeholders; for instance, incorporation of discourse between academic institutions and learners is denoted by double arrows in Figure 2.2. Buch et al. (2018) posit that the 7Cs framework ought to essentially be converted back into a dynamic learning design system. By including bi-directional communication between all the stages and restoring the iterative process within the 'Activities' stage to completely outline the ongoing feedback components within the design process, thereby allowing or adding a new richness to the student and supervisor relationship. Hence, this study uses the 7Cs framework as a fundamental base to design the ARI. The suitability of the 7Cs as an academic service quality lens is considered in this study for the student and supervisor relationship. The model consists of seven (7) stages and can be optimised for ARI needs with the following touchpoints and objectives:

Table 2.5. 7Cs framework functions and optimisation capabilities (Author)

Factor	Phase	Function	ARI Measurement	Programmable?
Conceptualise	Vision	Conceptualises what is the goal for the supervision intervention,	• What are type interactions between supervisors, students,	Yes.

		who is it planned for, what is the substance of the intervention, and what educational approaches are utilised?	and the learning environment • What the vision for the course is • What is the expected end	
Capture	Activities	What open-source academic resources are utilised and what other resources have to be created?	• A resource audits • Such as ensuring learning outcomes are made known from the very beginning	Yes.
Communicate	Activities	What are the various kinds of communication channels that can be utilised by the students?	• What is the degree of communication? • Level of engagement in discussions and keeping reflective evidence of how they relate to one another. • What is the polarity of the sentiment analysis between texts-based communications? • Timely Feedback.	Yes.
Collaborate	Activities	What are the various kinds of collaboration mechanisms will the students and supervisors engage in?	• Degree of collaboration • What mechanisms are used to foster collaboration • Guidance and support	Yes.
Consider	Activities	• What kind of reflective and demonstrative techniques of supervision are included? • Are the supervision results mapped to the activities and evaluation components of the intervention?	• Degree of consideration • What assessment strategies does the supervisor encourage or condone • Are the assessment's based on learning activities defined in the syllabus	Yes.

Combine	Synthesis	• What is the nature of the supervision intervention the students will engage with? What sort of supervision exercises will the students draw in with?	• Type of proposed engagement • Meetings and Catchup sessions • overarching views of the design	Yes.
Consolidate	Implementation	How viable is the plan? Do the various components of the plan supplement each other	• Executing and assessing the plan in a real learning context	Yes.

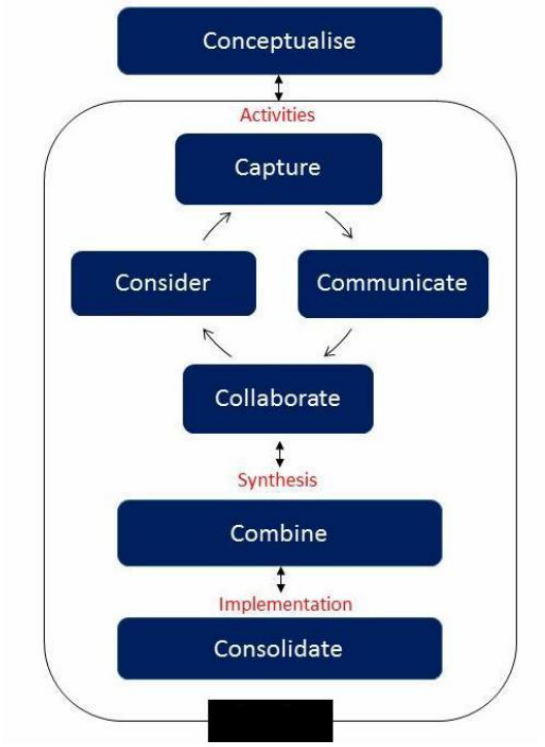


Figure 2.2. The 7Cs Framework (Buch et al., 2018)

In addition to the 7Cs framework of quality, there's an extension that can be used in conjunction with the 7Cs framework called the interactive aspects of the Case Scenarios 7Cs Framework (ICS7Cs) which provides a flexible framework for constructing a coherent narrative that supports an application-focused learning experience (Bundy & Howles, 2017). Derived from a well-established instructional method used for decades to promote course content transfer to real-world professional practice is case-based learning. Interactive Case Scenarios (ICS) are most effective for achieving application-level learning objectives involving decision-making in complex situations.

Although well suited for most professional programmes, ICS are applicable across nearly all disciplines to provide opportunities to develop professional expertise (Bundy & Howles, 2017). Table 2.6 indicates the different facets of the ICS7Cs Framework and its measurability.

Table 2.6. Interactive Case Scenarios: The 7Cs Framework (Bundy & Howles, 2017)

Objectives	Touchpoints	Measurable
Challenge	• Reframe learning objectives • Engage with a little creativity (Bundy & Howles, 2017).	Yes.
Context	• Usage of authentic or relatable situation • Content that has the immersive quality and it proves the depth of understating of a knowledge domain (Bundy & Howles, 2017).	Yes.
Characters	• Representing real-world situations and contexts. • Stories telling or usage of analogies to involve their interactions and challenges. • Mentee assumes a persona as an active decision-making agent in the narrative. (Bundy & Howles, 2017).	Yes.
Content	• Content that conveys compelling knowledge that reflects the realities and removes uncertainty. • It provides just enough understanding to carry the narrative and provide discipline-specific information at key junctures related to decision making. (Bundy & Howles, 2017).	Yes.
Choices	• Engaging supervision includes choices that are realistic and authentic. • Requiring the mentee not to struggle to weigh multiple options. (Bundy & Howles, 2017).	Yes.
Consequences	• From a mentor and mentee standpoint, the results of a choice in a scenario can be viewed as a form of consequential feedback. • Whereby the mentee observes the impact of a decision within a given context. • In addition, the prompt response from the mentor serves as part of this segment. (Bundy & Howles, 2017).	Yes.
Connections	• Constructing and delivering these types of learning activities requires supervisors to sufficiently introduce, facilitate, and debrief the case	Yes.

	scenario in a way to capitalise on the richness of this type of supervision experience (Bundy & Howles, 2017).	

The sentiments of the 7Cs framework for quality will be assessed using indexes and algorithms. In the contextual sense of adapting the 7Cs framework to an algorithm within the index theory's borders for the development of the academic rating index. This will be discussed in the next section.

2.5 Adaptation of the 7Cs Framework Criteria to Drivers of Academic Service Quality Tools and Technologies

This segment aims to discuss the objectives defined previously and layout a foundation for how they can be adapted to meet the research's expected end. It gives a view of how the research will be conducted.

2.5.1 7Cs Framework Adaptation to Ranking Scale (Likert)

Using the Likert scale logic, this study will enable students to assess and rank supervision quality through each criterion of the 7Cs framework. For instance, the aggregate output by all students across different geographies and timelines by the supervisor will help to understand better and measure supervision quality. The criterion will serve as intelligence for supervisors and institutions in better designing training to strengthen the perceived areas of weakness for supervisors and improve service quality.

2.5.2 7Cs Framework Adaptation to Algorithm

This study will follow a series of steps for dynamic programming as expressed in Table 2.4 of section 2.3. By definition, an algorithm is a series of steps that you expect will arrive at a specific solution (Hirsch, 2016). In this study, the following steps point-out how the 7Cs will be adapted into an algorithm:

- Establishing the rules of a problem.
- Exploring the problem space.

- Writing tests that would confirm the solution (Test Driven Development).
- Specifying the solution in steps to solve the issue.
- Converting each step into lines of code.

2.5.3 7Cs Framework Adaptation to A Relational Database

A relational database is a collection of records that organises facts factors with depicted connections for simple entry or ease of access. In the relational database model, the facts structures, including records tables, indexes, and views, remain partitioned from the physical storage, allowing directors to edit the physical records storage besides affecting the logical facts structure (Relational Database, 2020). The basic thumbs up about relational databases is that they empower clients to effectively categorise and keep data that can afterward be queried and sifted to extricate special information for reports. Relational databases are simple to stretch and aren't dependent on the real organisation. After the interesting database creation, an unused data category can be conveyed, barring all show applications being altered.
Reasons for opting to use a relational database as defined in Relational Database (2020) are as follows:

a) Accuracy: Data is saved just once, getting rid of information deduplication.
b) Flexibility: Complex queries are handy for users to join multiple tables to represent data in the view they desire.
c) Collaboration: Multiple users can get the right of entry to the same database.
d) Trust: Relational database fashions are mature and well-understood.
e) Security: Data in tables inside an RDBMS can be limited to get admission with the aid of solely precise users.

2.5.4 7Cs Framework Standardisation

To adapt the 7Cs framework to a standard, supervision content needs to be interoperable with different learning environments and be produced in a standardised way to maximise its reusability. In the words of Ahmed et al. (2007), state that educational software with the potential for online learning and interactions as complete package are developed, even on a commercial scale. However, they lack cohesion as an organised collection because every

software application is vertically engineered to comply within its specific domain. Hence, this research aims to adapt to standardisation of the Index in a vertical yet generic manner to accommodate every sphere of supervision across different disciplines. The aim of the ARI is to develop an environment for supervision objects that are interoperable, transparent, and sharable by the community of supervisors and students within the discipline, and to be accessible anywhere, any time.

Taken from the generic framework for the development of standardised learning objects within the construction-management discipline (Ahmed et al., 2007), depicted in Figure 2.3, aims to illustrate how a framework is developed or adapted by describing the various steps required to enable the application of the ARI standards and a set of concepts and categories in a subject area or domain that shows their properties and the relations between them for sharable supervision objects to serve the construction discipline.

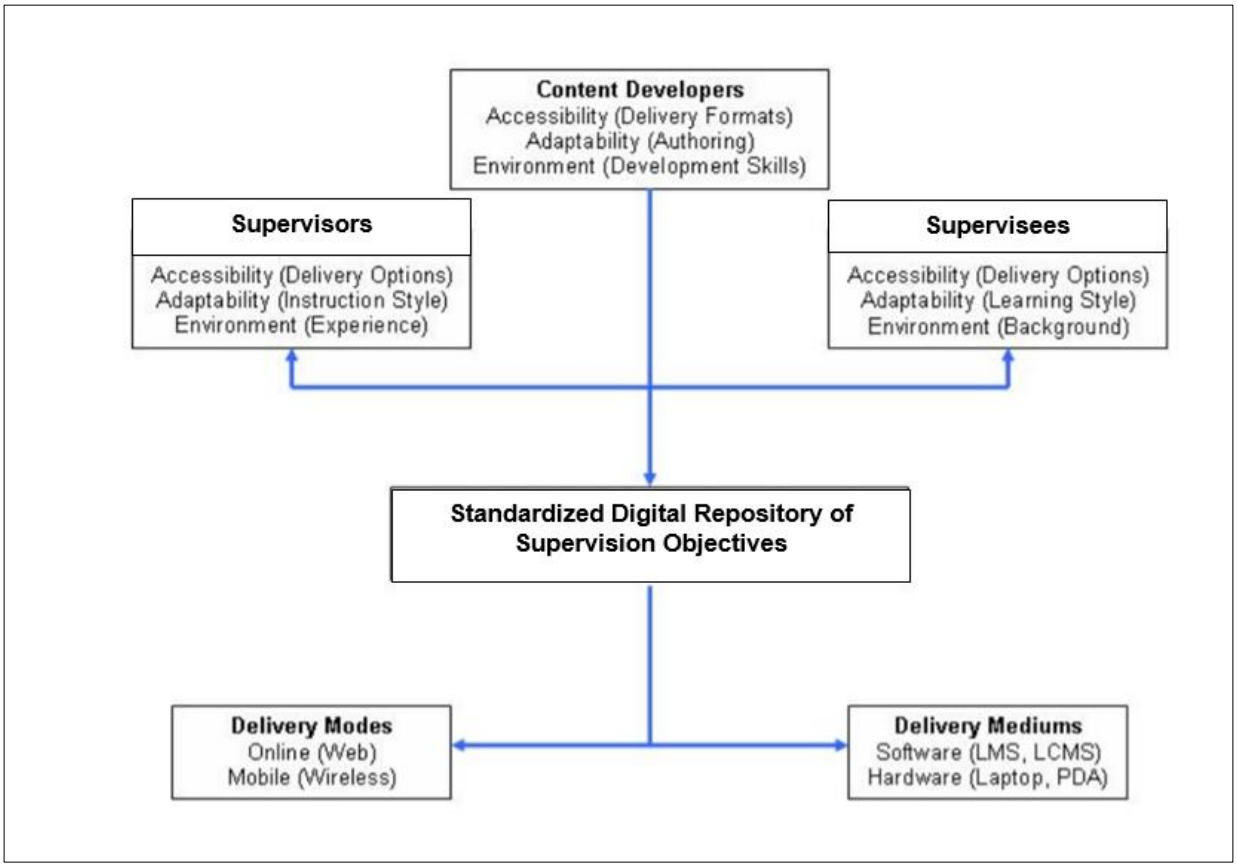


Figure 2.3. A conceptual model of how to standardise the 7Cs framework (Author)

Ahmed et al. (2007) state that, based on Figure 2.3, three main challenges face such developments to produce supervision objects:

- The intelligence of developing a system for relational metadata (a set of data that describes and gives information about other data).
- Accessible through various environments or platforms.
- Dynamic set of concepts and categories in a subject area and the semantic web concepts (Lehmann, 2009).

The contextual foundation paves the way to the conceptual framework of the ARI, as discussed below.

2.6 Conceptual Framework of the ARI

Conceptual modelling is a critical phase in simulation development by using diagrams to represent modelling and simulation centre (Aysolmaz & Demirors, 2008). This study sheds more light on the literature review for the different kinds of indexes and drilling down into how the ARI is categorised and how the integration of the different segments liaise with one another.

2.6.1 Components of the ARI

Focusing on the academic-sector and considering the above-mentioned facets of indexes, this study aims to generate an academic-staff rating index (ARI) to measure academic service quality. The indexes algorithm will convert the 7Cs framework to aggregate ratings per the criterion of the framework. The ARI's focus will be in evaluating the collaborative partnership and analyse specific fields of research and supervision metrics which measure the total number of supervisions the academic-personnel has engaged in to reflect on the yearly average level of ranking by the students to recent supervisions published on the site. Most importantly, the tool will help to reflect the areas of weakness and strength from the knowledge of the subject, accountability, and delivery using the 7Cs frameworks as a basis for measuring supervision.

Figure 2.4 is a scale or full-size model of a design used to illustrate the design evaluation and the architectural flow of data across the system. It provides at least part of the functionality of a system and enables testing of a design. The topological illustrations in Figure 2.4 are segmented into five domains:

a) Supervisor domain

b) Student domain
c) Rating Processing Engine domain
d) On-Premise Administration domain
e) Universities central verification database domain

The ARI domains are conceptualised to serve as a glue to the web and mobile application, which can be accessed using the Internet, thereby allowing the student and supervisor to interact with the platform from any place in the world.

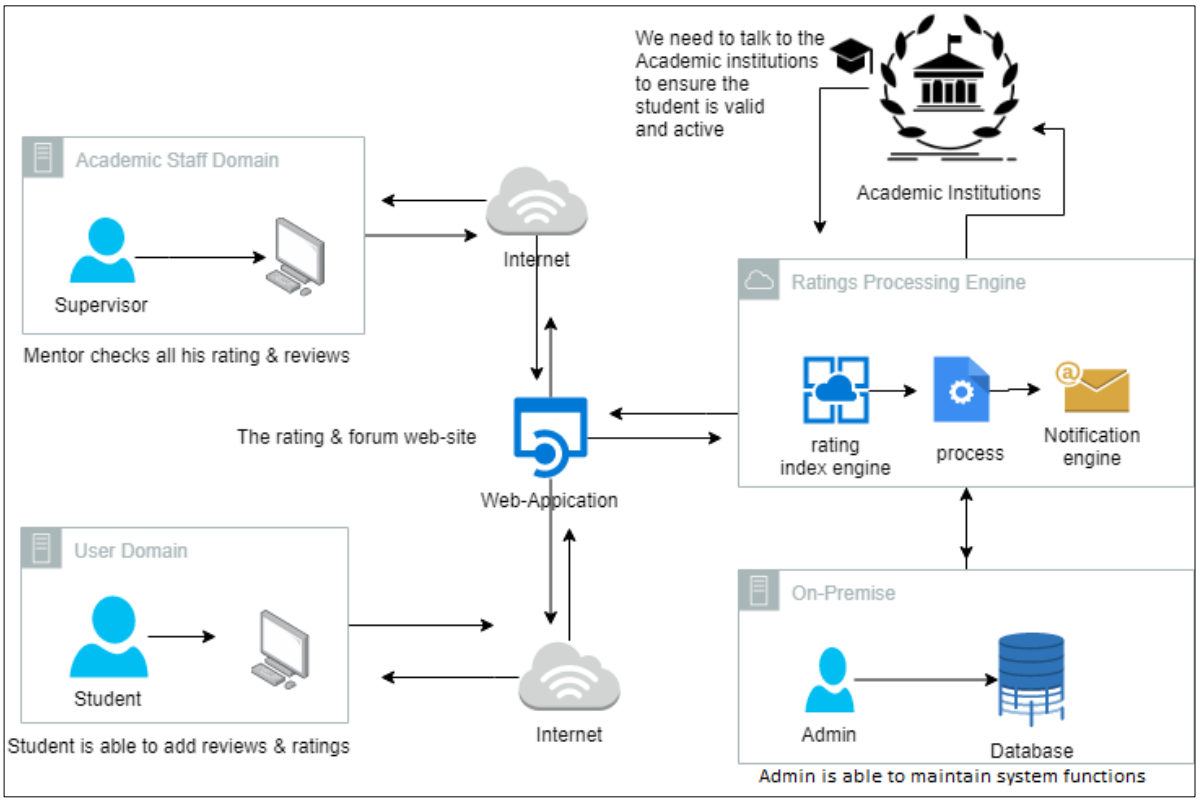


Figure 2.4. High-level mock-up of the system interactions and processes (Author)

2.6.2 Supervisor Domain

This domain's key focus is to give the supervisor the ability to view their aggregated ARI scores, check the reviews, and leave comments. This allows them to see their profile and gives them the ability to search or check other supervisors as well.

Table 2.7. Key functions of the supervisor (Author)

Functions	Purpose

View reviews against his or her name.	Be aware of the incidents raised against them, lest their reputation be ruined.
Respond and resolve the problems addressed in the review.	To show enthusiasm and keenness to address the issues raised.
Maintain improve the supervisors ARI.	Ensure that one can raise the ranks and be deemed as a credible supervisor.
Able to maintain and upkeep their user profile.	To ensure safety and security.
Get a report on the ratings they have received.	To see a trend line report of the progress of themselves.
Raise tickets for fraudulent behaviour in the event they suspect malicious activity against their name or account.	To prevent fraud.
Verify profile accounts.	To avoid impersonation and identity fraud.

2.6.3 Student Domain

This domain's key focus is to give the students the ability to create reviews, search supervisors, and engage in commentary discussions.

Table 2.8. Key functions of the student (Author)

Functions	**Purpose**
Create an account or profile	Ensure that a valid student is validated against the institutions/universities' central database.
Create, Update and Remove reviews	The main activity to be fulfilled by the user
Search for the supervisor.	Allow the student to locate the correct supervisor they want to rate.
Engage in forum	Here students can put their issue publicly and discuss with each other.
Student relationship management	Allow putting their problems in front of higher authority by direct inbox messaging capabilities, and the authority can reply or resolve the problem and provide a timely response to the students.

2.6.4 Rating Processing Engine Domain

This domain's key focus is to enable the engine to process the computations that make up the aggregation and perform system functions like notification, verification, and validation of reviews.

Table 2.9. Key functions of the central operating system (Author)

Functions	Purpose
Aggregate the reviews into an ARI	To enable the supervisor to be aware of their score.
A dependable, impartial, clear, transparent, current, and fair score	To avoid unfairness and criminality
Liaise with the universities central database to only allow valid students to do reviews	To ensure that only legitimate students partake in the reviewing process
Routine support procedures and batch processes; monitor results to ensure batch production completion within service level guidelines.	To provide monitoring metrics, among others, network utilisation, CPU load, and disk space consumption.
Send out notifications.	Push notifications are small messages that can reach audiences anywhere and anytime through the medium of the mobile-app.

2.6.5 On-Premise Administration Domain

This domain's key focus is to give the system administrator the ability to maintain records of the application such as users, user roles and permissions, auditing, the ability to remove inappropriate and malicious content from being published in the community.

Table 2.10. Key functions of the administrator (Author)

Functions	Purpose
Raise internal inquiries on what appears to be fraudulent reviews.	Provide a clear consulting communication channel.
Provide reports and system health-checks to ensure a fair index	Provide application performance information and participate in periodic support compliance audits
Administer system-wide stability	Online monitoring, administration, and support of 3rd Party applications running on various platforms

Create, escalate, and enquire operational Incidents in accordance with the organisation's incident management policies and procedures. Ensuring that the tickets can be traced.	Perform proactive analysis of failures and trends on 3rd Party applications and data to improve service levels
Always ensure accurate and timely updates to Incidents. Ensure the communication of incidents, and status updates are of high-quality and contain accurate and up to date information	Ensure service is provided within customer Service Level Agreements, Management of appropriate processes maintaining and supporting incoming incidents and requests.
Provide the proposed system with valid students to minimise fraudulent behaviour, thereby producing an incorrect ARI.	Notify supervisors in the correct manner and time of any incident detected that impact the supervisor credibility, provide info, distribute, and present incident reports to a predefined list of supervisors.
Perform real-time monitoring of vital Trusted Internet Connections (TIC) connections	Comply with the business footprint shift requirements of the support team

2.6.6 Academic Institutions Central Verification Database Domain

The key focus of this domain is to give the system a 3rd party verification mechanism.

Table 2.11. Key functions of the institution's integration (Author)

Functions	Purpose
Student Information System	Maintaining a physical record of all your students is useful for administration purposes, and so is storing that information for ease of access by ARI
Student Searching	Offer easy-to-use search and sort features, making it easy for users to find a specific student in the database through an API
Student Reporting	Reporting harmful content and behaviour from students enrolled with the Institution

2.7 Chapter Summary

This chapter has provided a brief overview of the different types of indexes, computing theory, the nature, and types of algorithms available in the market. Furthermore, it has discussed the importance of the 7Cs framework and how it can be incorporated into being a driver of service quality in the academic sphere.

The adaptation of the 7Cs Framework Criteria to Drivers of Academic Service Quality Tools and Technologies was discussed with multistage phases as to how the 7Cs can be adapted

to a ranking scale, algorithm, relational database, and how it can be standardised across all academic levels.

3 CHAPTER 3: RESEARCH DESIGN AND RESEARCH METHODOLOGY

This chapter aims to discuss the research methodology used to conduct the research ranging from technical to mathematical techniques. The research methodology solves the research problem systematically. It may be understood as a science of studying how research is done scientifically.

3.1 Research Paradigm

According to Antwi and Hamza (2015), every research is based on a few basic philosophical suspicions that constitute valid research. While various paradigms exist, this study chose the pragmatism paradigm. Rahi (2017) posits that this paradigm's point is to discover the shortcomings within the study and fortify it by utilising the blend method approach.

A researcher who opts to use this paradigm accepts that the mixed method approach can obtain genuine knowledge. Rather than the method or approach being the most vital aspect of the study, the issue under scrutiny is the most important and researcher ought to utilise all approaches to understand how the issue can be resolved (Rahi, 2017). As a result, the pragmatism paradigm holds to the following characteristics in the knowledge claim position:

a) Consequences of actions
b) Problem-centred
c) Pluralistic
d) Real-world practice-oriented

Because pragmatism is not associated with any system or reasoning, this research aims to employ it, thereby enabling the researchers to use both quantitative and qualitative approaches. At the minimum, one is to discover the finest methods and research procedure that will help unravel and solve the research problem (Rahi, 2017).

3.2 Research Approach

This research aims to study the different steps that a researcher generally adopts in studying a research problem alongside the logic behind them. It is however very necessary to know not only the research methods or the techniques but also the methodology (Kothari, 2008). According to Kothari (2008), research methods can be put into qualitative, quantitative, and mixed methods approaches, as discussed below.

3.2.1 Qualitative approach

Qualitative methods are informed by an interpretive worldview. They can be seen in some of the characteristic words, researcher involvement, participant viewpoints, small-scale studies, holistic focus, flexible, processual, natural settings, and inductive than deductive reasoning (Daymon & Holloway, 2005; Teherani et al., 2015). A qualitative approach to research is concerned with subjective assessment of attitudes, opinions, and behaviour. Research in such a circumstance may be a work of the researcher's bits of knowledge and impressions. Such an approach to research generates results either in non-quantitative form or less thorough quantitative examination. Generally, focus group interviews, projective techniques, and depth interviews, are used in this typical research (Kothari, 2008; Connelly, 2016).

3.2.2 Quantitative approach

The broadscale point of quantitative research is to classify features, number them, and build measurable models to clarify what is being observed (Sidel et al., 2018). Quantitative research deals with numerical-figures, rationale, and an objective position as it focuses on numeric and constant data and point by point merged reasoning instead of divergent reasoning, to aid generate ideas in an unconstrained and spontaneous manner (Daymon & Holloway, 2005; Nassaji, 2016).

a) The data is usually gathered using structured research instruments.
b) The results are based on larger sample sizes that are representative of the population.
c) The research study can usually be replicated or repeated, given its high reliability.
d) All aspects of the study are carefully designed before data is collected.
e) The research uses tools, such as questionnaires or computer software, to collect numerical data.

3.2.3 Mixed approach

The mixed methods approach accommodates a wonderful set of thoughts and practices that separate the strategy from the main research qualitative and quantitative research approaches. The origins of blended techniques research can be traced to its use amongst fieldwork sociologists and cultural anthropologists early in the twentieth century (Clark et al., 2008; Creswell, 1999; Johnson et al., 2007). In his paper, Denscombe (2008) argues the following point to connote how the mixed approach is characterised:

a) Both the quantitative and qualitative methods are implemented within the same research study.
b) A research design that indicates the chronological order and severity that's given to the quantitative and qualitative components of data collection and analysis.
c) An explicit account of how the quantitative and qualitative aspects of the research relate to each other, with a heightened emphasis on the way triangulation is used.
d) Pragmatism as the philosophical underpinning for the research.

3.2.4 Justification of the study's research approach

The quantitative research approach is suitable for this study due to the quantitative tools that helped determine whether the developed system was usable and reached for its purpose in line with the aim of this study of developing an ARI. The development of the ARI involves algorithms and computational mechanisms, which are highly quantitative, hence the usability of features and insights that are quantitative like the Likert scale and algorithms. The development of the ARI will be mainly quantitative (algorithms and programming). The testing and refinement of the ARI will be done through a computer lab-based process where students, supervisors, and university personnel simulators will offer insights into the application's usability.

3.3 Data Collection

Data collection is the process of gathering quantitative records on precise variables to evaluate consequences or glean actionable insights. Good data collection requires a clear method to ensure that certain the data you accumulate is clean and usable, consistent, and dependable (Dimagi, 2019). One way of representing the data collection process is through the circle of

interrelated activities. The circle best displays the process of engaging in activities that encompass amassing data and beyond (Creswell & Creswell, 2017).

According to QuestioPro (2021), quantitative data collection has various methods, ranging from experiments to controlled observations, surveys, longitudinal studies, polls, telephone interviews, and face-to-face interviews, classified as primary data, which refers to first-hand experience data (Hox & Boeije, 2005). Quantitative data collection also has the secondary classification of data which refers to already existing data that can be accessed using other means like reports and the likes (Johnston, 2017).

Quantitative data is predominantly linked to figures and numbers. Researchers depend on quantitative data when they expect to evaluate traits, states of mind, behaviours, and other characterised factors with a rationale to either back or restrict the speculation of a particular marvel by contextualising the data collected through the various above-mentioned methods (Palinkas, 2015; Sandelowski, 2000; Sapsford and Jupp, 1996). Figure 3.1 demonstrates the various types of collection methods found in a quantitative study based on their level or severity.

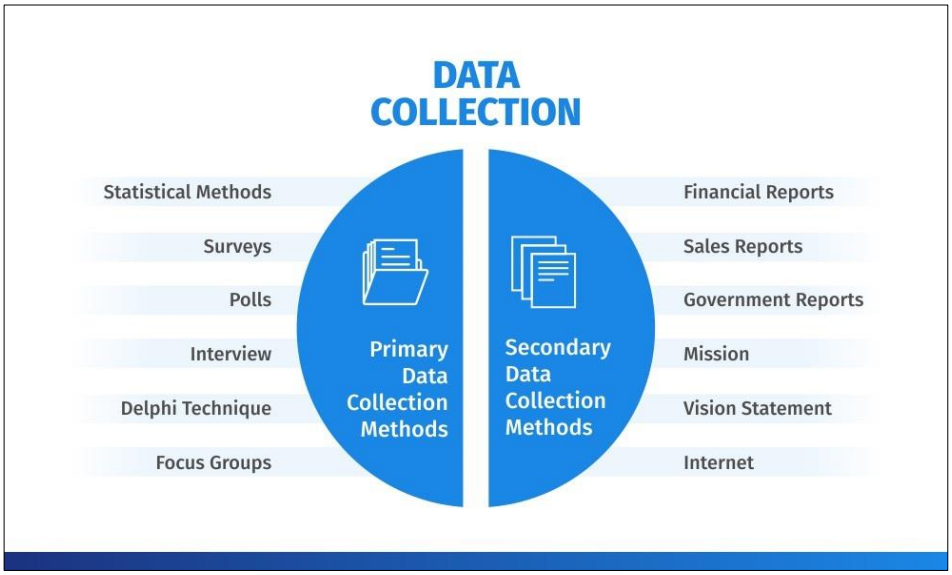


Figure 3.1. Quantitative data collection methods (QuestionPro, 2021)

Quantitative data collection has two major categories: discrete and continuous. The discrete type deals with finite numbers and the steady data values falling on a continuum with the plausibility to have divisions or decimals. An example would include, finding the number of students who like a particular supervisor. With the continuous type on the other hand, mainly

gets utilised when the researcher wants to get an understanding of the population's physical traits such as age, height, and location (Sogunro, 2002; QuestionPro, 2021).

This study will employ observation of mobile application's performance during system testing of different aspects of the app; hence, data is mainly collected through the review of mobile application components. In particular, how the system responds to its expected rating performance from a 5-point Likert scale questionnaire comprising of 43 questions in total. Each question is classified and aimed at revealing certain characters and features of the supervisor. This implies that this study followed observation as one of the primary data collection methods and the discrete category quantitative approach.

3.4 Data Analysis

Ogino and Tanaka (2014) describe data analysis as the method of bringing order, structure, and meaning to the mass of gathered data, which is depicted as chaotic, vague, and time-consuming, but furthermore as an inventive process. Carroll and Moran (2011) also define data analysis as an observational venture seeking to analyse behavioural and statistical information in which the successive judgement of activities has been preserved. In quantitative data analysis, researchers are anticipated to turn raw numbers into significant information via the application of rational and necessary thinking. Quantitative information evaluation might also consist of the calculation of frequencies of variables and the differences between them. A quantitative approach is commonly associated with discovering evidence to both aid and/or reject hypotheses the researchers have formulated in the early stages of the research process (Dudovsky, 2016). As this study is mainly quantitative, data analysis with the application of statistical software, the analysis follows Carroll and Moran's (2011) of observing the software application's behavioural patterns by running and analysing several tests that consist of the following stages:

a) Preparing and checking the data input of information into the system.
b) Selecting the most suitable tables and diagrams to use according to the research objectives.
c) Selecting the most appropriate statistics to describe the data.
d) Selecting the most appropriate statistics to examine relationships and trends in the data.

3.5 Reliability and Validity

Artstein (2007) state that reliability can be effectively and efficiently measured using accuracy, stability, and reproducibility. Validity is characterised as the extent to which an idea is meticulously assessed in a quantitative study (Heale & Twycross, 2015). Validity aims to decide whether the study uses genuine planning processes to measure how honest the investigation results or outcomes of the study are (Joppe, 2000; Golafshani, 2003).

Reliability aims to show an instrument's accuracy under test, analysis, or scrutiny (Heale & Twycross, 2015). Joppe (2000) expresses his thoughts on reliability as the degree to which the outcomes of a study are steady over time and have a precise representation of the total add up of a population of data under the study. It is alluded to as unwavering quality, and if that can be replicated under a comparative technique, then the investigation instrument is dependable.

To ensure that the scores' computations are done using available verified ratings from valid students, the study added a feature on a mobile application that checks the reviewers' validity with the respective institution. In terms of the algorithmic computations, the study followed the verified Wilsons score interval which has been applied widely in industry and scholarly fields. Following an established algorithm method provides a dependable, reliable, and valid measure of accuracy, stability, and reproducibility as defined by Artstein (2007).

3.6 Ethical Consideration

This study was based on a computer lab-based approach; therefore, there is no risk of harm or need for consent. The key ethical compliance is the intellectual property of the university guiding this project. Further is to ensure that any form of conversation regarding the study is completed with honest and transparent virtues. The study has followed well-established algorithms (Wilson Score, 2020) to avoid misleading statistics, and ensure better representation of the application's information and performance.

3.7 Chapter Summary

A detailed plan of execution was tabled in this chapter, providing a clear road map for the research paradigm and approach that will be taken to ensure that the research objectives of the study are met. Further, the chapter details data collection techniques and methods of ensuring validity and reliability of the study. In a nutshell, the chapter outlined the research methodology for the study and has motivated which methods are suitable to achieve the objectives of this research. The coming chapter will address the implementation of the ARI applications.

4 CHAPTER 4: SYSTEM DESIGN AND IMPLEMENTATION

This chapter presents the methods, technologies, and frameworks used to design, implement, and develop the academic rating index (ARI) applications. This chapter will highlight the system design, requirements, and implementation at the system level that describe the functions that the system should fulfil to satisfy the objective defined earlier to lay down the requirements using an appropriate combination of diagrams, views, and sketches.

4.1 System Requirements

Looking at the ISO900, the purpose of the system requirements analysis is to transform the user-oriented view of desired services and properties into a technical view of the product that meets the operational needs of the user as stated by Hoyles (2017). This process builds a representation of the system that will meet stakeholder requirements and that, as far as the limitations allow, does not suggest any particular implementation. It results in quantifiable system requirements that specify, from the user's point of view, what performance, and non-performance characteristics it must possess to meet the defined functionalities and features (ISO, 2015). Following an agile approach, the diagram depicted in Figure 4.1, indicates the various processes involved the Agile process. The Agile methodology is an iterative, time-boxed, people-oriented, and result-focused approach to shipping software programs. It is designed to deliver small features and functionality for testing, in an incremental manner, rather than shipping out the full program at the end of the project cycle (Agile Software, 2020). After gathering the requirements, the design process commences, and iterates for the project's length or duration. This is vital because development and testing happen iteratively before shipping out the application to production.

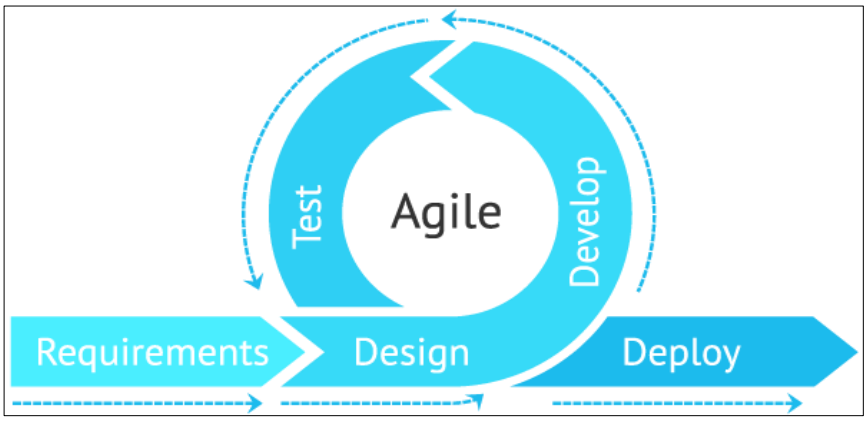


Figure 4.1. Agile Methodology process (Agile Software, 2020)

Furthermore, the agile methodology is adjusted with the values and standards portrayed within the agile manifesto for computer program development. In line with this guideline, prerequisites and plans are assessed persistently; teams have a normal component for reacting to change rapidly (Agile Software, 2020).

Inside the paths of programme development, agile is characterised as hypermedia headway established on the irregular extension. It understands work and issues through organising groups. It could be a well-ordered venture control that advances solid leadership and workers' adjustability. Its objective is to supply a high-grade administration framework to meet the objectives and the client's needs (Insights to Agile, 2020). The key standards, and how agile development in a general sense varies from the more conventional waterfall approach to software development, are as follows as defined by Principles-of-Agile (2020):

1. A collaborative and agreeable approach between all partners is fundamental.
2. Testing is coordinated all through the venture of the software lifecycle, test early and frequently.
3. Application of the 80/20 rule.
4. Completely finishing off a feature before starting a new one.
5. Focus on the frequent conveyance of features.
6. Develop small, incremental releases and iterate.
7. Create requirements at a high level, lightweight and visual.
8. Requirements may change, but the timescale is fixed.
9. The team must be empowered to make decisions.
10. Active user involvement is highly critical.

The agile process or discipline has a range of methods that can be executed to ensure that the principles of the overarching agile process are achieved. Below is the list of agile methodologies as defined by Cohen et al. (2003).

1. Extreme Programming (XP): Based on the philosophy of 4 eyes one screen, this encourages two or more people to look at the same code base while developing; this increases productivity and outcomes.
2. Scrum: This is a process that acknowledges that the development process is erratic, as a result it formalises "the do what it takes approach" on the tasks at hand and has found success with various independent software merchants.

3. The Crystal Methods: These methods are developed to address one of the major limitations: poor communication and the crystal techniques address in product development.
4. Feature Driven Development (FDD): Developed in the 1990s, FDD is based on the development of an overall model, the building of a features list, and designing and building by feature.
5. Lean Development (LD): Derived from the automotive industry, LD is more of a management philosophy than a development process. Team size, new release length, team distribution, and machine criticality are not directly addressed.
6. Dynamic Systems Development Method (DSDM): DSDM is not so much a method as a framework. The DSDM lifecycle has six stages: pre-project, achievability study, trade study, functional model cycle, design and build cycle, execution, and post-project.
7. Agile Modelling (AM): It is based on values, concepts, and practices that focus on modelling and documentation of software.

Table 4.1. Characteristics of reviewed Agile Methods (Cohen et al., 2003)

	XP	Scrum	Crystal	FDD	LD	DSDM	AM
Team Size	2-10	1-7	Variable	Variable	**N/A**		
Iteration Length	2 weeks	4 weeks	<4 months	<2 weeks			
Distributed Support	No	Adaptable	Yes	Adaptable			
System Criticality	Adaptable	Adaptable	All types	Adaptable			

Following an agile approach, this study found it best to subscribe to the scrum agile methodology for its ability to accept changes in requirements, even late in development, because the software development cycle is an unpredictable process. It assumes that engineering requirements continue through the lifetime of a system, thereby bringing about a different set of mentality that is driven to do all it takes to ensure that the requirements are met, and the system is functional.

Figure 4.2 provides a brief highlight of the scrum methodology process and various stakeholders present in the value chain. The product owner grooms the backlog, which is a set of stories that have been broken down into small actionable tasks (Birkinshaw, 2018; Oomen et al., 2017). Then the team meets together for the sprint/iteration cycle planning,

where they discuss the objectives of the iteration of work and the number of tasks, they wish to deliver at the end of the 1-4 weekly cycle (Bibik, 2018). The scrum master then facilitates that the items that the team has committed to are fulfilled without any hindrances, with a daily scrum meeting held by the team to ensure that the items/tasks are still on a cause to the set predefined end-date (Eckstein, 2013; Birkinshaw, 2018; Beck et al., 2001). Having done all this successfully, at the end of the cycle, the team converges again to discuss the difficulties encountered and how to change the process to accommodate the flavour of the team since agile is not a cast and stone that does not allow or accommodate change. Then the process starts from the very beginning again (Schwaber & Sutherland, 2018).

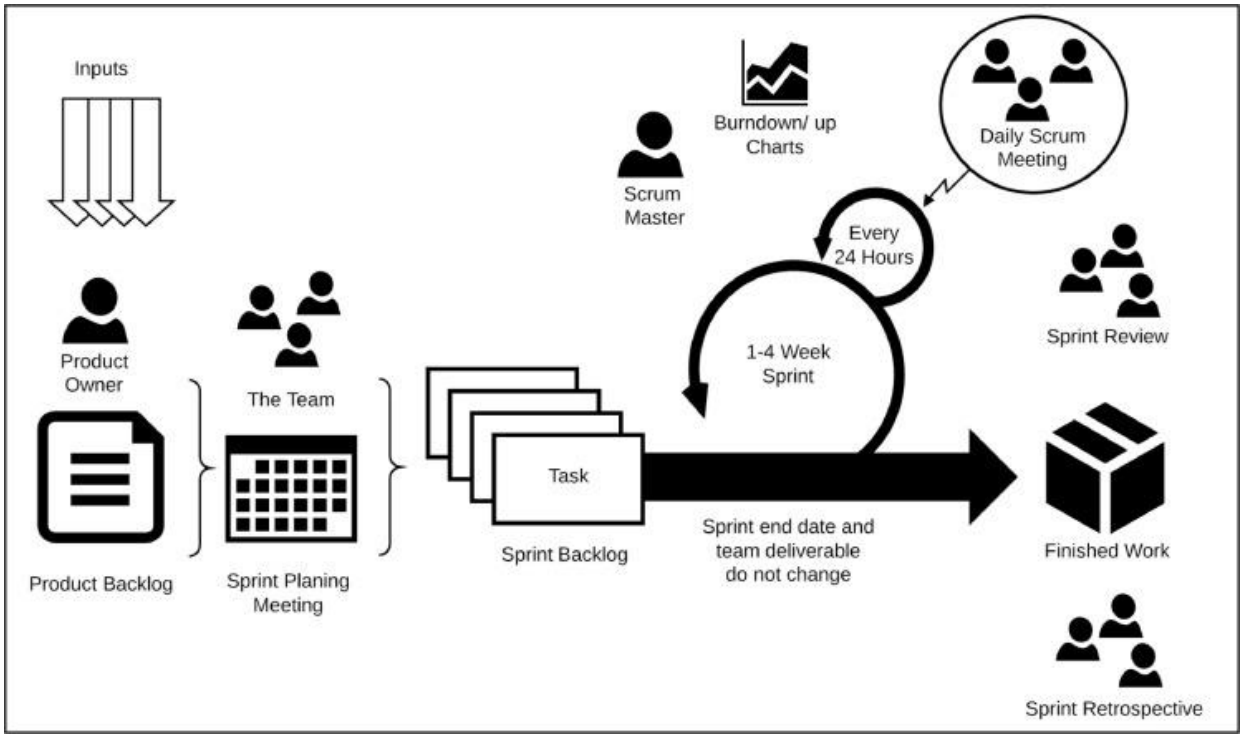


Figure 4.2. Scrum Framework as defined by Schwaber & Sutherland (2018)

As a result, this study uses user-stories, which are a few sentences in simple language that outline the desired outcome. A user story is a tool used in agile software program development to capture a description of a software requirement from the client's perspective. A user story describes the kind of user, what they what and why they want a certain feature (visual-paradigm, 2021). A user story helps to create a simplified description of a requirement. They do not detail how the feature of the requirement will be met but offer just enough information to make sure the development team has the light of the outcome. Requirements are added later, once agreed upon (Lucassen et al., 2016). User-Stories also aid development because of the following main advantages.

- Focus on the user
- Enable collaboration
- Drive creative solutions
- Creates momentum

A user story is a lightweight approach for quickly taking pictures of the "who", "what," and "why" of a product requirement (visual-paradigm, 2021). Figure 4.3 gives us an example of how one should create a user story.

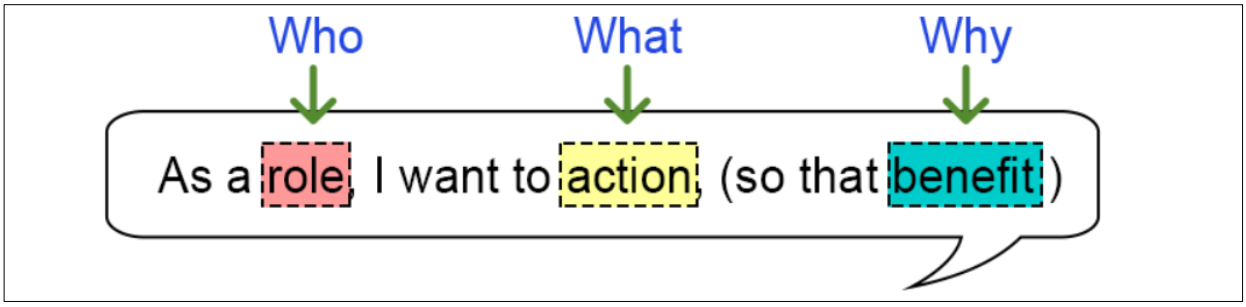


Figure 4.3. User story template (visual-paradigm, 2021)

Following the guidelines defined in Figure 4.3 and Table 4.2, show the high-level details of the examples of the user-stories that this body of work aims to achieve.

Table 4.2. Example of a list of main flow User-Stories for the ARI system (Author)

AS A	I WANT TO	SO THAT
Student (mentee)	Create a rating review against my supervisor	I can have an opinion and contribute to the improvement of my society academically.
Supervisor (mentor)	See and query my rating and score	So that we drive a high-performance culture towards supervision
System Admin	Ensure optimal performance	So that the system is always working
University Stub	The student logging the review is registered and valid	To avoid fraudulent behaviour

4.2 System Architecture

System architecture speaks to the placement of these software elements on physical machines. Two closely related components can be co-located or placed on distinct machines. The elements' place will also affect performance and reliability (Paganini, Fierro, & Subramaniam, 2021). Put differently, it is a generic discipline to take care of objects (existing

or to be created) referred to as "systems", in a way that supports reasoning about the structural properties of these objects (Golden, 2018).

The segmenting of an application's code-structure differs from developer to developer to limit complexity and reduce code duplication. To attain a layered architecture, ASP.NET Boilerplate follows the standards of domain-driven design (DDD). In expansion to DDD, there are moreover other consistent and physical layers in a present-day architected application. Based on the development principle being adhered to, this project has been developed using the Nlayer-Architecture, provided for by aspnetboilerplate (Technology, 2020). There are four basic layers linked to DDD: the presentation, application, domain, and infrastructure layer, with each performing the following tasks:

- **Presentation Layer**: Provides an interface to the client, can also be referred to as the logical layer.
- **Application Layer**: Intercedes between the Presentation and Domain Layers. Coordinates business logic to perform application assignments.
- **Domain Layer**: Incorporates trade objects and their rules. Usually, it is the heart of the application.
- **Infrastructure Layer**: Gives bland specialised capabilities that bolster higher layers for the most part utilising 3rd-party libraries.

Other extension layers include:

- **Client Applications**: Provides a visual representation to remote clients that use the application as a provider with the aid of HTTP APIs (Mobile App, Web Apps, and 3rd party consumers).
- **Distributed Service Layer:** This layer generally includes Authorisation, Caching, Audit Logging, Object Mapping, Exception Handling and Session capabilities.

Considering this project's nature, the DDD proved to be the most suitable fit and would enable faster delivery using Rapid Application Development. Figure 4.4 is adapted from aspnetboilerplate Technology (2020) to highlight the NLayered architecture's different components and how they integrate into a full framework.

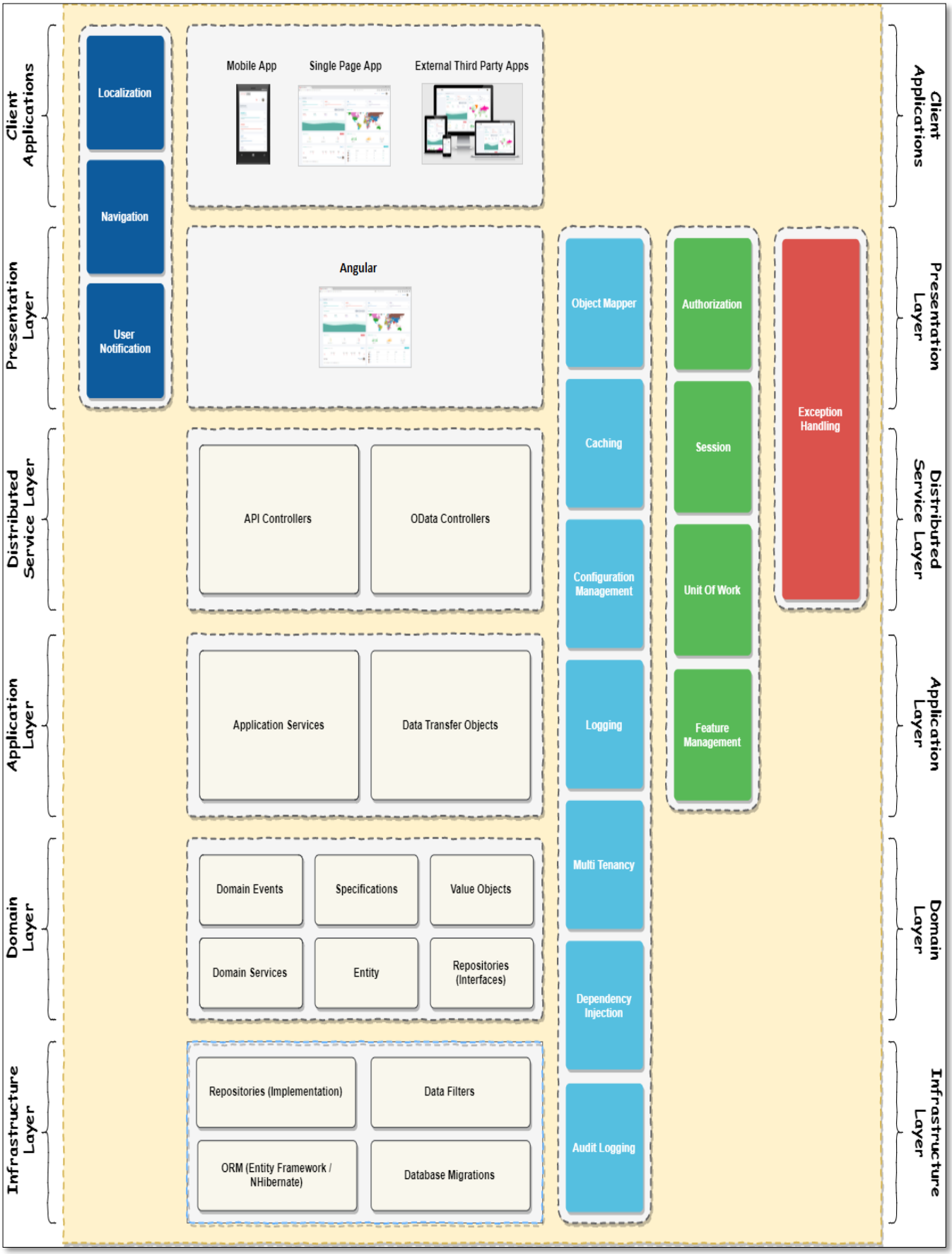


Figure 4.4. ASP.NET Nlayer-Architecture (Technology, 2020)

ARI application is hosted on the Microsoft Azure cloud platform, as depicted in Figure 4.5. The whole ecosystem of the application is mainly wrapped around the .net framework and restful service-driven architecture. With C# being the main language of development, there are multiple other languages that come into play to fulfil the objectives defined in the latter pages of this work. As per the Azure service cluster portion, the app is segmented into 3 portions: The Database, Application Programming Interface (API), and the front-end (view/visual representation).

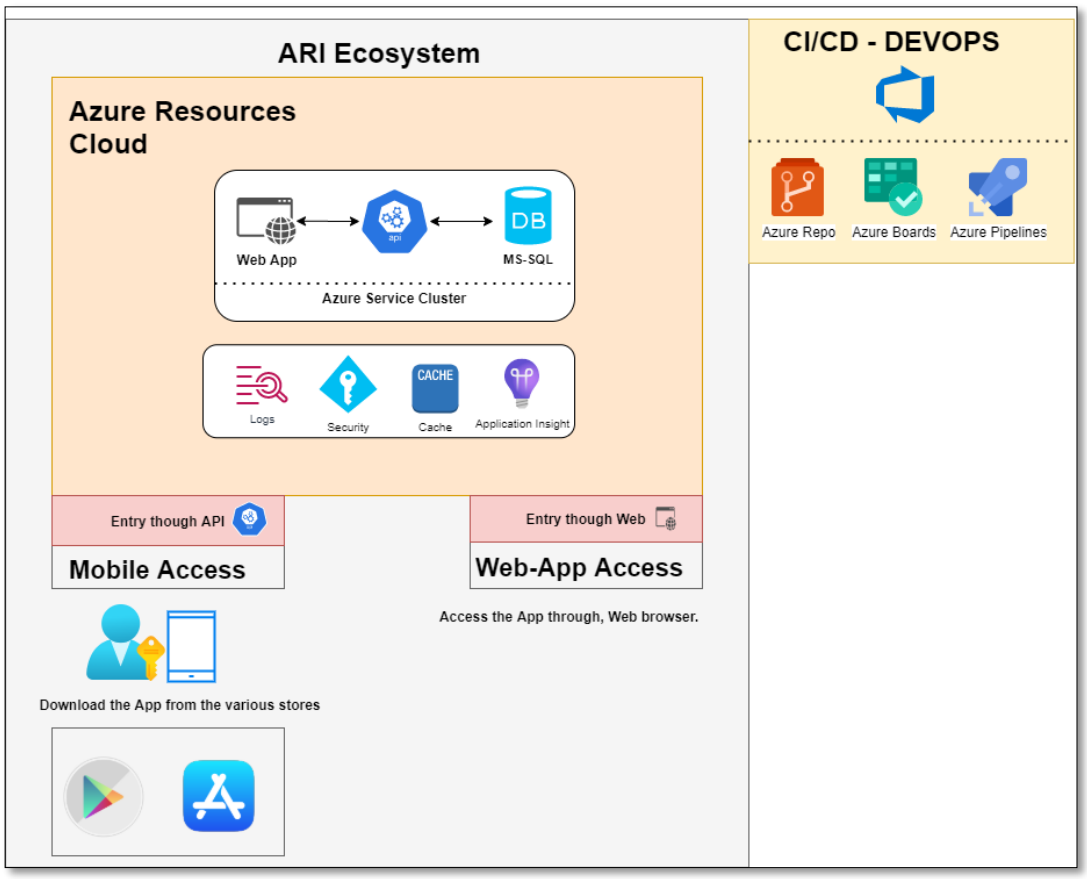


Figure 4.5. ARI High-level ecosystem (Author)

The three (3) segments used for the separation of concern can be noted below in detail:

- Database: **Azure MS-SQL**

  Used to store the data and every transaction in the system, the database runs on an instance of Azure SQL resource. Azure SQL database is the shrewdly versatile, relational database benefit built for the cloud. It's evergreen and continuously up-to-date, with AI-powered and robotised highlights that optimise execution and solidness for the application; its Hyperscale capacity choices naturally scale assets on request

allowing the user to focus on application and not on the storage sizes (Azure SQL database | Microsoft Azure, 2020)

- API: **Azure App Service**
  Used a glue between the front-end and the back end (database), the API serves as a mediator to transport data across and perform system-specific business logic. APIs primarily existed for the exchange between two or more programmes (IBM, 2016). Using Azure allows for quick building and deployment of the API enabling productivity and innovation (App Service | Microsoft Azure, 2020). Embedded with a simplified operation, the developer has access to intelligent and interactive diagnostics, application insight, and monitoring.
- Front-End: **Azure App Service (WEB)**
  Primarily used to display a view to the client or user of the application, this is used to maintain the administrative functionalities of the app. Written in angular, this is mainly a single page application needed to maintain the system's database records such as user and roles management, auditing, reviews, and ratings. It is communicating with the API using a secure HTTPS line.

4.3 System Design

Systems design is the method of characterising elements of a framework like modules, design, components, and their interfaces and data for a framework dependent on the predefined prerequisites. It is the technique of characterising, creating, and planning frameworks that satisfy the specific desires and prerequisites of a business or association (The Economic Times, 2021). The system design procedure consists of defining software and hardware architecture, components, modules, interfaces, and statistics to allow a system to fulfil a set of well-specified operational requirements. It is centred around the idea of characterising the clients wishes and required features of the system early within the development cycle (Rasmussen, 2003).

This section on system design shows us the different kinds of indexes and looking more into how the ARI is designed in components and how they liaise with one another and implement the system with proper and effective use of available resources. The ARI's hardware and software architecture includes use-case, class diagram, entity-relationship diagram, and flowcharts discussed in the subsequent sections.

4.3.1 Use-case Diagram

Use-cases are a contextual design method developed for the high-quality exchange of understanding from architects to other system experts and stakeholders involved (Boban et al., 2018; Kulak & Guiney, 2012). Using Unified Modelling Language (UML), a use-case can address a list of moves or event steps, generally defining the interactions between an actor and the system to reap a goal or requirement (McGlinn et al., 2016). The ARI's detailed system design is connoted in the use-case diagram depicted in Figure 4.6 to show the different actors and how they interact with the system. The health report in this instance refers to the monitoring of a set of activities performed on/by a system to keep it in a operable or functional state, making the admin aware of any anomalies that may arise (Kothamasu et al., 2006).

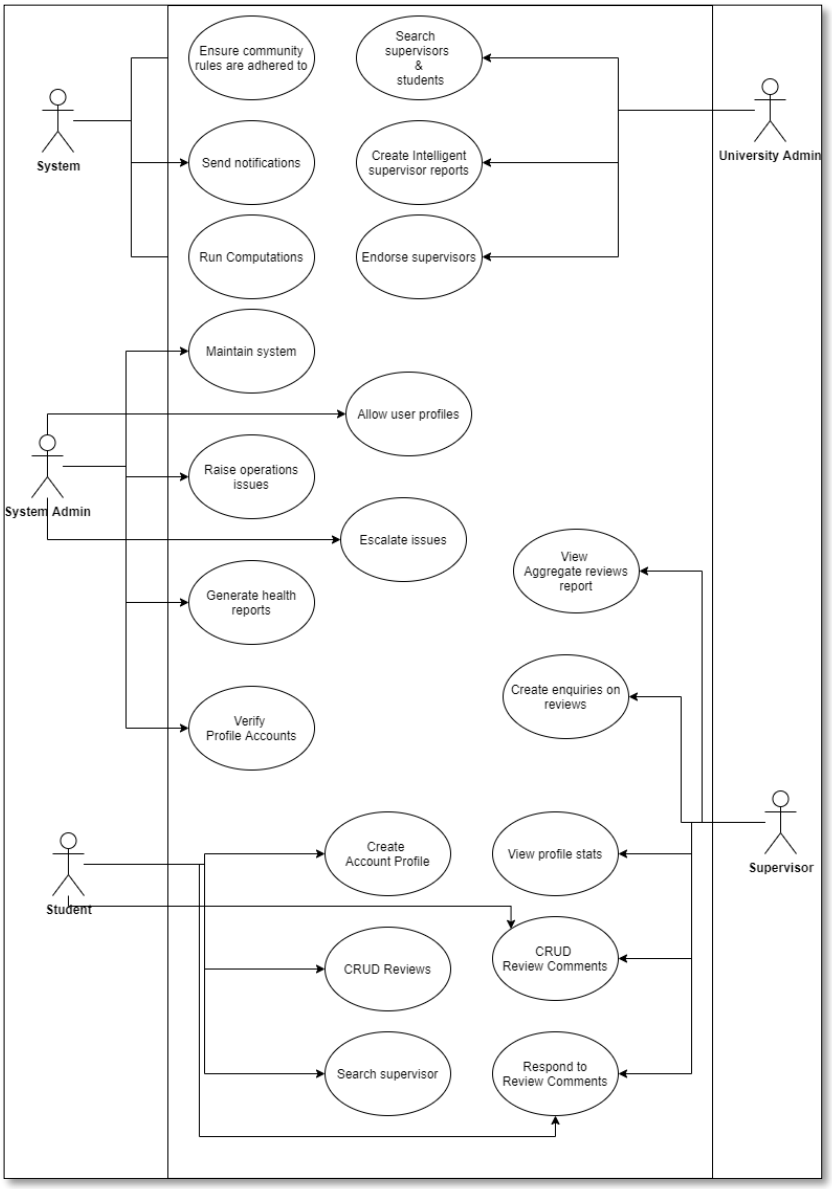


Figure 4.6. Use-Case diagram displaying all actors interacting with the system (Author)

4.3.2 Class diagram

The class diagram is used to visualise the granular levels of an application by describing the different aspects of the system, thereby describing the attributes and operations of a class (UML - Class Diagram - Tutorialspoint, 2020). Figure 4.7, provides light to the attributes and methods found in the classes, depicting how the application service implements the interfaces and the methods at their disposal.

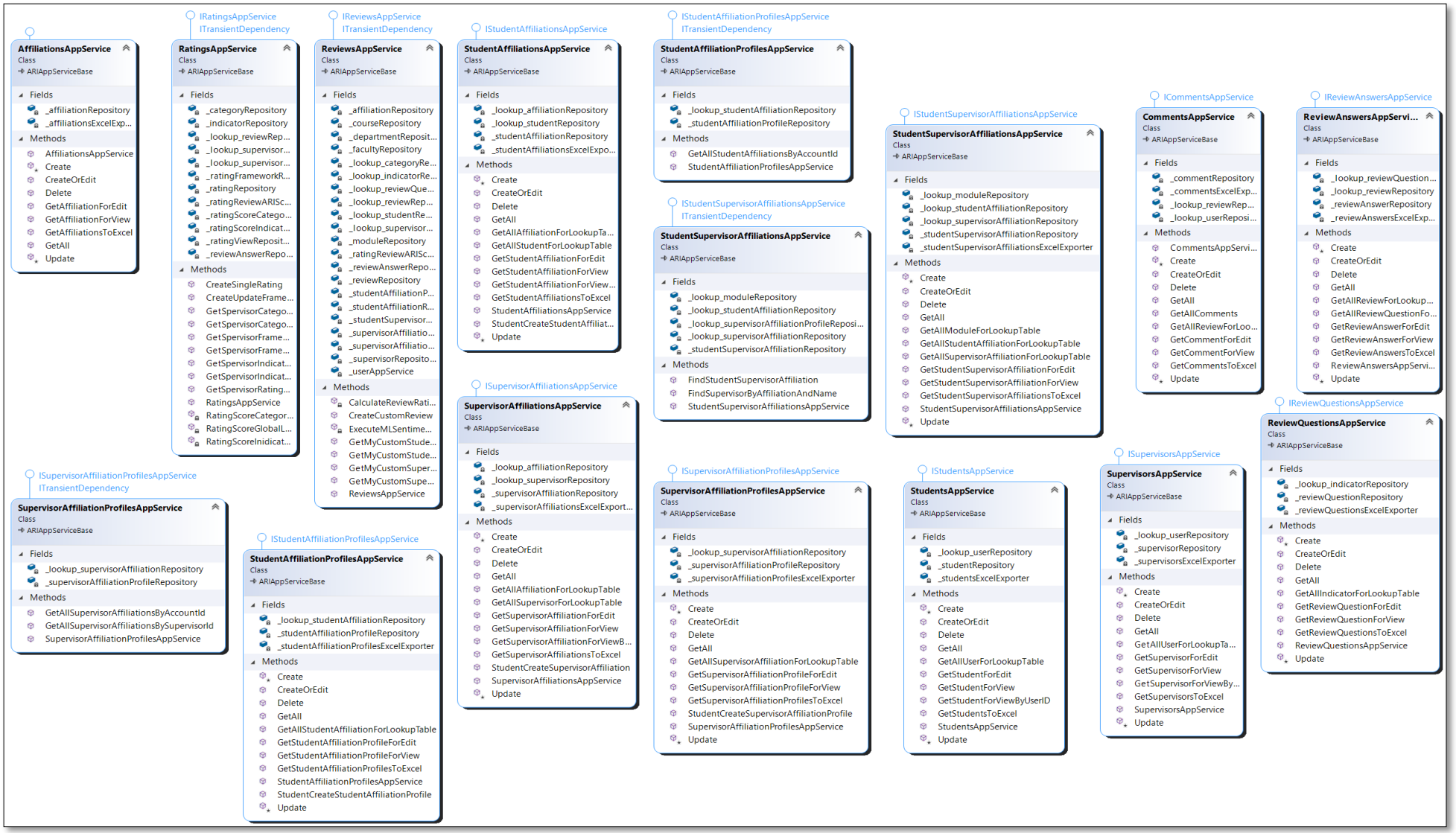


Figure 4.7. ARI Class diagram (Author)

The student-app and supervisor-app services that can manipulate and return a list of registered individuals can be observed from the class diagram above. Following the student-app and supervisor-app is a review-app-service which entails all the records that the students have created against the supervisor. Each review is tagged or linked to a comment-app-service, which records all the comments made for a review that has been marked as valid. Similarly, the review answers-app contains 43 answers that the student has answered in the app that is also linked to a specific student, supervisor, and review record. All the questions are stored and retrieved using the review-questions-app. The affiliation-app serves as a record keeper and retriever of known universities globally, and each student and supervisor will have one or more affiliations, hence the student-affiliation-app and supervisor-affiliation-app. Similarly, each student has a relationship with a supervisor, hence the student-supervisor-app, which serves as an aggregate table to join the two entities.

4.3.3 Entity-Relationship Diagram

An entity-relationship diagram fundamentally views how the database structure is set up and how the different tables relate to one another (What is Entity-Relationship Diagram, 2020). Figure 4.8 displays the ARI application structure in terms of the classes that make up the entire ecosystem.

The main features of the ARI are categorised as follows:

- **Person**: It represents the aspect of a human being and the different entities that can be derived from the person's class. It is composed of a student and supervisor as users.
- **Affiliation**: This segment is mainly focused on the person's relation/affiliation to an institution. This will also show the aggregate relationship between a student and the supervisor.
- **Institution**: This segment speaks to the aspect of the school where the relationship occurred. It is necessary to have these records so that the system can build its own records instead of depending on universities or higher learning institutions that have bespoke course offerings and school structure.
- **Review**: The review namespace holds to light the ratings made by a student in account to a supervisor and the various 7Cs framework categories and questions that will be posed.

- **Indexes**: Finally, indexes speak to the statistical computations that will be due to the reviews and ratings brought forth by the students.

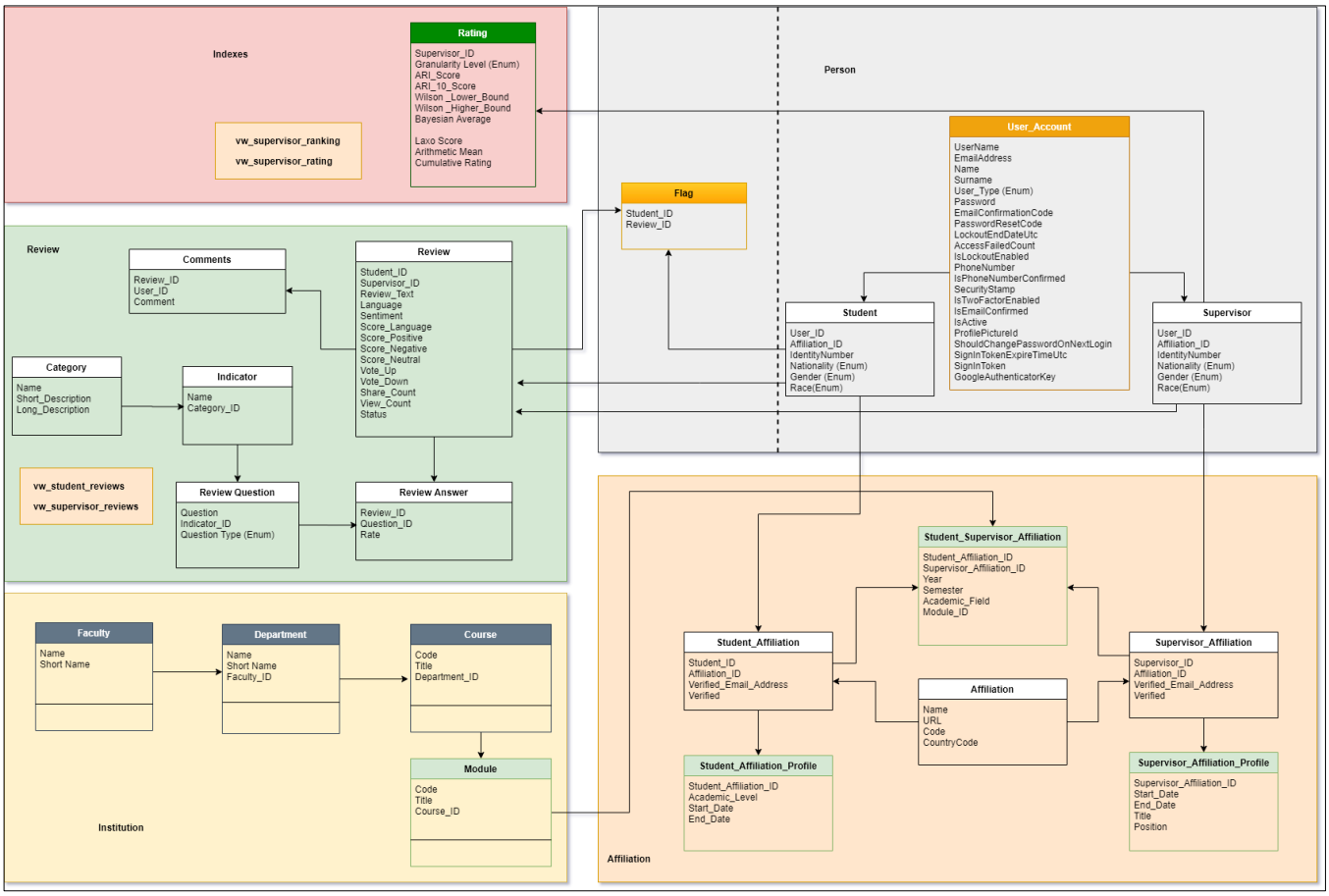


Figure 4.8. ARI entity-relationship diagram (Author)

4.3.4 Flowchart diagram

A flowchart visualises a sequence of actions, tasks, or operations through pictures to communicate end-to-end events and interactions. It can also be referred to as components for programme visualisation (Chapin, 2003; Gavrilova et al., 2016; Lai et al., 2003). Figure 4.9 provides a brief high-level UML diagrams that reveal how the different actors interact with the system. In particular, the flowchart shows that the action will be invoked by the student, who will complete an online form and post it. Data collected from the user-form will be processed for sentiment analysis, verification, and validation. Following validation and assessment of language, the post is added to the queue, where it shall be processed and persisted to the database.

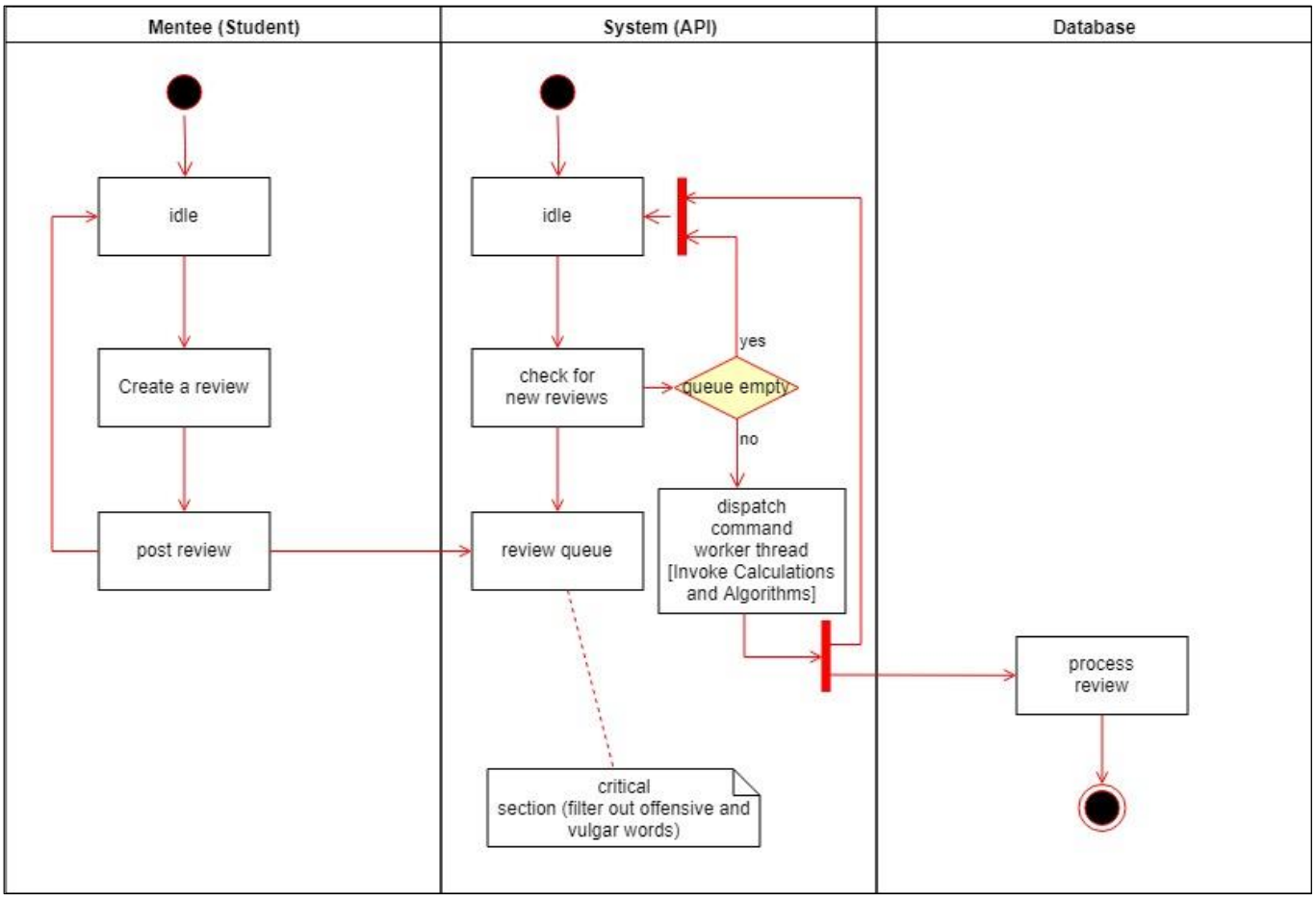


Figure 4.9. Student main basic flow (Author)

The following process flow depicted in Figure 4.10 gives us a brief overview of the interaction between a supervisor and the system. We see how the supervisor gets notified once a review has been logged against them and thereby giving them to query the validity of the request and accept the score.

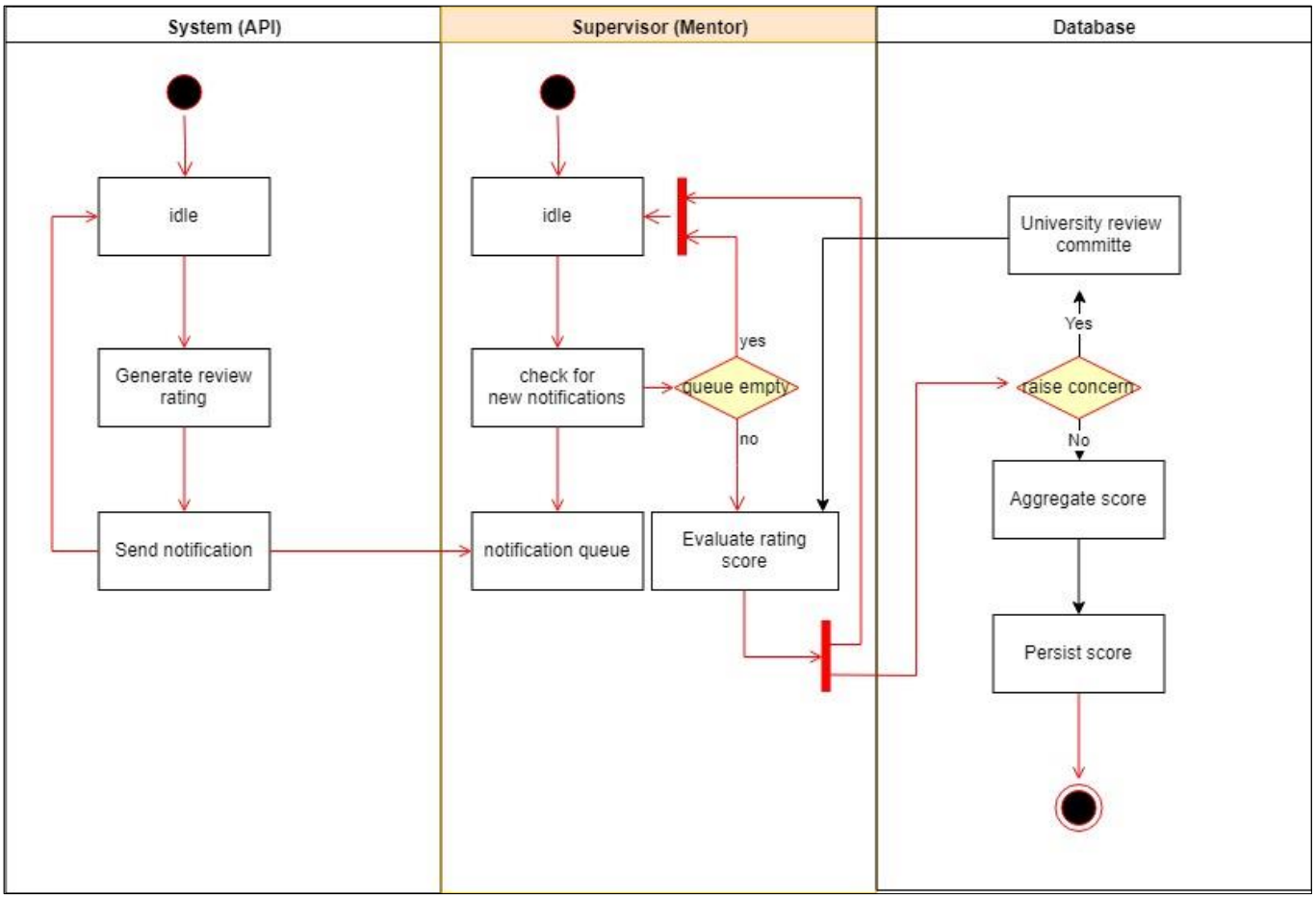


Figure 4.10. Supervisor main basic flow (Author)

The following process flow gives a brief overview of how the ratings are derived. In Figure 4.11 the student makes the request and the algorithm is invoked to check if the output thereof is above 60%. Only if the output reaches the condition does the ARI values get incremented with a value of 1.

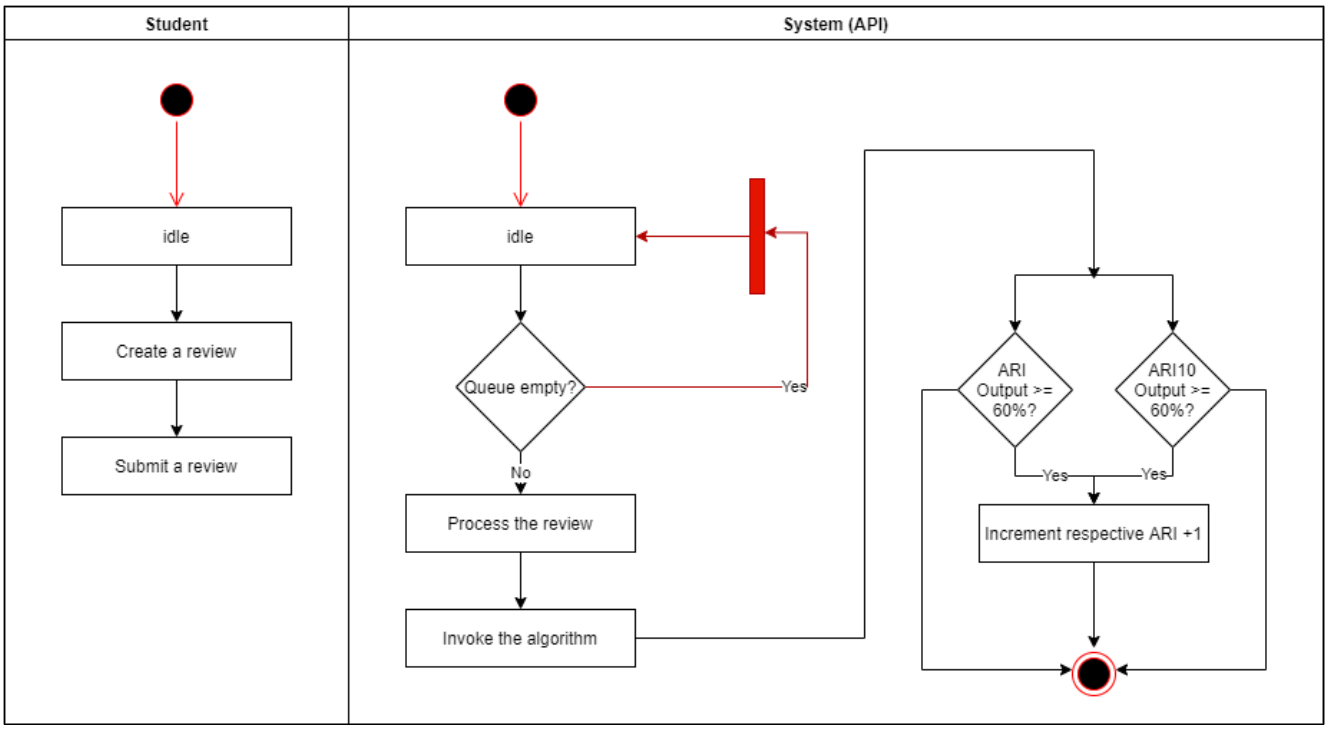


Figure 4.11. The basic flow of how the ratings are derived (Author)

4.4 Implementation of the ARI Algorithm

The details of how the technical components come together to build up the ARI ecosystem are explained in the section. System implementation speaks about the characterisation of how a system ought to be built, guaranteeing that the system is operational, utilised and ensuring that the system meets the quality standard (Systems implementation, 2021).

4.4.1 Technical requirements

The ARI is segmented into multiple applications that come together to make up the entire ecosystem, namely the front-end for administration purposes, a mobile app to be used by both students and supervisors, and an API to serve as an engine of operation, to handle all the business logic and transactions.

Table 4.3 indicates the minimum technical requirements needed to run the applications in different environments in the software development lifecycle.

Table 4.3. Development specifications (Author)

Specification	Backend (API)	Front-end (Client)	Mobile (Application)
Operating System	Windows 10	Windows 10	Windows 10
Memory	8GB	8GB	8GB
Storage	250GB	250G	250G
Platform	64bit	32-bit or 64-bit	32-bit or 64-bit
Programming Language	C#	Angular	Ionic Framework (Angular)
Runtime Compilation	.Net Core 3.0	NodeJS 10.0	NodeJS 10.0
Database	MSSQL	Local Storage	Local Storage, Ionic Storage and Cache Database
Package manager	NuGet package	NPM	NPM and YARN
Integrated Development Environment (IDE)	Visual Studio	Visual Studio Code	Visual Studio Code
Accessibility	Browser windows	Browser window	Android IOS

4.4.2 Technology stack

The application is written on top of the ASP.NET Boilerplate template using the modern architecture. It provides a SOLID development experience for the programmer with the usage of common market technological tools. Figure 4.12, indicates the technology that gets used, and Table 4.4 indicates in detail the version.

Figure 4.12. 3rd party technologies used to build ARI (Technology, 2020)

Table 4.4. List of libraries and technological frameworks (Author)

Technology	Purpose	Mode	Version

.Net Core	As the main development language for the business logic and the API, this helps with cross-platform adaptability.	Backend (API)	3.0
Entity Framework	To serve as a link between the API and the database, thereby calling the data records with ease	Backend (API)	6.0
Microsoft SQL Server	For the maintenance of databases	Backend (Database)	2014
Angular	Develop a speedy and adaptable code base that fast and efficient for the front-end	Front-end (Web)	8.2.3
Angular Material	Help customise the UI to be responsive and adapt to different screen sizes	Front-end (Web)	8.2.3
SignalR	Real-time notification ability	Front-end (Web)	1.0
AutoMapper	To help alleviate the hustle of code having to map classes/objects to one another.	Backend (API)	10
Redis	It is used for caching purposes, thereby allowing the application to run faster.	Backend (API)	6.0
Identity Server	It is used for .Net to build identity and access control solutions for modern applications, including single sign-on, identity management, authorisation, and API security.	Backend (API)	4.0
Bootstrap Less/CSS/SASS	For styling of the front-end	Front-end (Web)	
Swagger	It is used for a visual representation of the API endpoints	Backend (API)	13
Ionic Framework	For the development of the hybrid mobile application	Front-end (Mobile)	5.0
Hangfire	For ease of background processing without a windows service	Backend (API)	1.10

4.4.3 Backend (API)

The API is developed using the ASP.NET Boilerplate (ABP) framework. Which uses a host of open-source technology-stacks that are well-supported, documented and maintained. ABP is not simply just a framework, it additionally provides a strong architectural model based on domain-driven design, with all the best practices, procedures, and guidelines in mind.

Pre-requirements

- Ensure your computer has visual studio installed
- .Net Core 3.0 also must be installed.

Development process

- Create an app and download the template from the aspnetboilerplate website (Technology, 2020).

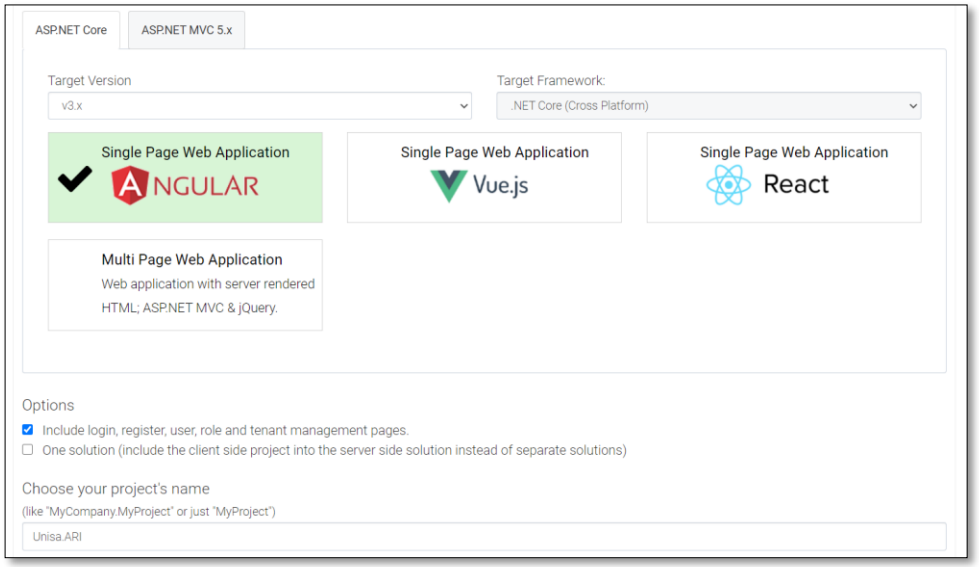


Figure 4.13. ASP.NET project creation screen (Technology, 2020)

- ABP will create a template with all required features such as login, user management, auditing, and localisation.
- Open the solution in visual studio and then restore all the NuGet packages.
- Once All downloaded, start the application by **Ctrl+F5**; the API will then be accessible using the browser.

4.4.4 User interface (UI)

The angular JavaScript library, driven with typescript, was the main technology used to develop the UI for both mobile and web administration applications. Angular has proven to be a suitable technology for the front-end. It has many support and other 3rd party components that can be used for plug and play without development a lot from scratch, such as angular material (Team, 2020). The UI applications will be rendered working assuming that the API (backend) application has been started in visual studio.

4.4.4.1 Mobile Application UI

The following steps will be followed to get started with the mobile app.

Pre-requirements

- Ensure your computer has Node.js installed
- Ionic apps are created and developed mainly through the Ionic command-line utility
- To ensure that the installation was successful, using the terminal or command prompt run the following commands
    - node – version
    - npm – version

Command-line activity (Existing App)

- Install the Ionic CLI: **npm install -g @ionic/cli** (-g alias installs the package globally)
- Download the code base for the ARI mobile app
- Restore and download all the dependencies using the command: **npm install**
- To run the app, use the **ionic serve**

Command-line activity (New App)

- Install the Ionic CLI: **npm install -g @ionic/cli** (-g alias installs the package globally*)*
- Create an Ionic app using one of the pre-made app templates: **ionic start ARI tabs**
- To run the app, use the **ionic serve**

When successfully compiled, the application will be served locally: http://localhost:8100 and the Remote Service Base URL/API endpoint: http://localhost:5000 meaning that the mobile app will communicate with the API using that 5000 port when running locally. Figure 4.14 depicts to us how an app that has successfully compiled will look like.

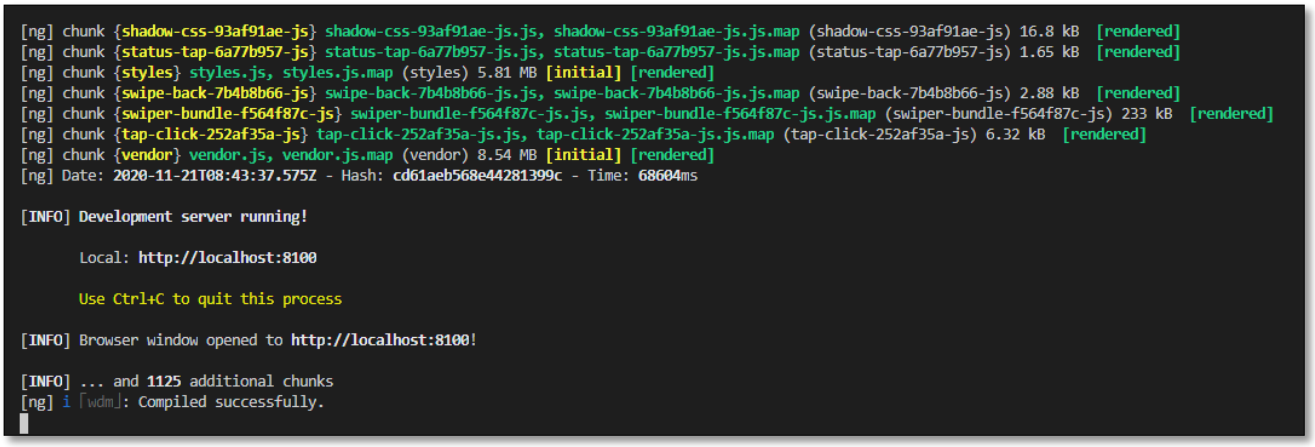


Figure 4.14. Command-line interface of the compiled mobile app (Author)

4.4.4.2 Client Web Application UI

The following steps will be followed to get started with the client web app.

Pre-requirements

- Ensure your computer has Node.js installed
- Angular apps are created and developed primarily through the Angular command-line utility
- To ensure that the installation was successful, using the terminal or command prompt run the following commands
    - node --version
    - npm –version

Command-line activity (Existing App)

- Install the Ionic CLI: **npm install -g @angular/cli** (-g alias installs the package globally)
- Download the code base for the ARI angular front-end app
- Restore and download all the dependencies using the command: **npm install**
- To run the app, use the **ng serve**

Command-line activity (New App)

- Install the Ionic CLI: **npm install -g @angular/cli** (-g alias installs the package globally)
- Run the command line interface command ng new and enter the name of your app: **ng new Unisa-ARI**
- To run the app, use the **ng serve –open**

The command “ng serve” starts the server, takes program files, and builds or bundles the app. As the developer makes changes to the files. Similar to the mobile app, the web-application will be served locally in: http://localhost:4200/ and the Remote Service Base URL/API endpoint: http://localhost:5000 meaning that the mobile-app will communicate with the API using that 5000 port as demonstrated in Figure 4.15.

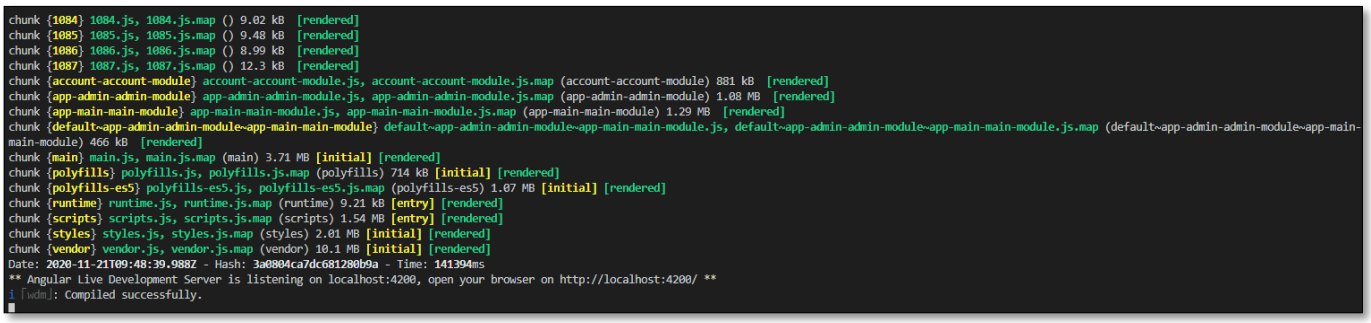


Figure 4.15. Command-line interface of the compiled web app (Author)

4.4.5 Algorithm

The ARI app used the binomial proportion confidence interval in the Wilson score for statistical computing algorithm. The binomial distribution is the distribution of observations when there are solely two feasible outcomes; for example, a coin toss could either be a head or a tail. Another example is the like button in an e-commerce application. It Is either the consumer likes the product or not (Ghanmi et al., 2011). Wilson score estimates the population chance from a pattern likelihood when the likelihood follows the binomial distribution. As a result, it produces a range of probabilities with an anticipated self-belief interval (Wilson score in Python-example, 2020). The binomial distribution was used to determine the number of students who share a positive or negative sentiment in ratings towards their supervisor based on various points. The rationale for considering Wilson score and binomial distribution, instead of calculating the average of the ratings or the difference between the positive and the negative ratings and use it as a deciding factor, is because of the following reasons:

Example1: Imbalanced ratio

Difference = (Positive ratings) − (Negative ratings)

Score = Average rating = (Positive ratings) / (Total ratings)

Why it is impartial/Unfair:

Table 4.5. An indication of the imbalanced ratio when using the average (Author)

	Positive reviews	Negative reviews	Total reviews	Difference	Score
Supervisor1	600	400	1,000	200	60%
Supervisor2	5,500	4,500	10,000	1000	55%

Looking at Table 4.5, assuming that supervisor1 has 600 positive ratings and 400 negative ratings, the outcome yields a 60% positive average rating. In the same light, if supervisor2 has 5,500 positive ratings and 4,500 negative ratings, the same calculation yields a 55% positive average rating. The example leaves supervisor2 with a total of 10,000 ratings, but only a 55% positive score, and supervisor1 with total ratings amounting to 1,000 but a 60% positive sentiment score. This is impartial and does not reflect the true sentiment of the entire population, considering that supervisor2 has got more reviews in terms of the difference.

Example 2: Zero negative ratings

Difference = (Positive ratings) − (Negative ratings)

Score = Average rating = (Positive ratings) / (Total ratings)

Why it is impartial/Unfair:

Table 4.6. An indication of the impact zero rating can have on averages (Author)

	Positive reviews	Negative reviews	Total reviews	Difference	Score
Supervisor1	20	0	20	20	1
Supervisor2	100	30	130	70	0.0769

As such, average rating works fine if both ends of the stick have equal or more ratings but inadequate for imbalanced proportions. To illustrate the latter, take the second hypothetical example depicted in Table 4.6 of supervisor1 with 20 positive ratings and 0 negative ratings. And supervisor2 with 100 positive ratings and 1 negative rating. Using the calculation based on average, the algorithm's outcome gives an advantage to supervisor1 because of fewer negatives, even though supervisor2 has more positives.

Due to the above scenarios, this study uses the lower bound of Wilson score confidence interval for a Bernoulli parameter to adjust the level of the rankings with the vulnerability of a little wide variety of perceptions. The Wilson score confidence helps determine with 95% confidence what the real fraction of a positive rating or sentiment is (Miller, 2020). The lower bound on the proposition of the positive rating is given by the following equation in Figure 4.16, by considering only the positive and negative ratings.

$$\left(\hat{p} + \frac{z^2_{\alpha/2}}{2n} \pm z_{\alpha/2}\sqrt{[\hat{p}(1-\hat{p}) + z^2_{\alpha/2}/4n]/n}\right)/(1 + z^2_{\alpha/2}/n).$$

Figure 4.16. Wilson score equation (Bender, 2001)

where

- *p̂ = (# of positive ratings)/ (Total ratings)*
- *n = Total ratings*
- *Z_(α/2) = Quantile of the standard normal distribution*
- *The z-score for a 95% confidence interval is 1.96.* (Please see Appendix B for the z-score)

The concept right here is to treat the existing set of consumer rankings as a statistical sampling of a hypothetical set of consumer scores from all users and then use this score. This can help predict with 95% confidence what the general population would be willing to upvote or have a positive sentiment towards the subject matter based on the sample at hand (Wilson Score, 2020). This means that if we have an idea of what a sample student population thinks about a supervisor based on the ratings, we can estimate the preferences of the whole community.

The Wilson score interval, developed by the American mathematician Edwin Bidwell Wilson in 1927, is a self-assurance interval for a statistical population share. It assumes that the statistical pattern used for the estimation has a binomial distribution (Wilson score interval, 2020). The Wilson score interval can be used to estimate by either looking at the positive and negative ratings or considering a scale. If the supervisor is rated on a 5 -star scale, for example, we can then attribute the following conversions 1-3 would carry a negative sentiment, and 4-5 would carry a positive sentiment.

The equation can be used to calculate two values:

- Wilson Lower Bound score
- Wilson Higher Bound score

Below we see the figures of the calculations in code-form depicted in Figure 4.17, as used in the ARI application.

- We first find the z-score, which will serve as a constant value of **1.96**
- Calculate the Wilson denominator

  $$denominator = 1 + z ** 2/n$$
- Calculate the Wilson centre adjusted probability

  $$centre\_adjusted\_probability = probability = p + z * z / (2 * n)$$
- Calculate the Wilson adjusted standard deviation

  $$adjusted\_standard\_deviation = sqrt((p * (1 - p) + z * z / (4 * n)) / n)$$
- Lower bound score depicted in Figure 4.17

  $$(centre\_adjusted\_probability - z * adjusted\_standard\_deviation) / denominator$$

```
5 references | Thapelo Mokole, 47 days ago | 1 author, 2 changes
public double WilsonLowerBound(double positiveScores, double totalScores)
{
    if (totalScores == 0.0)
        return 0.0;

    double phat = 1.0 * positiveScores / totalScores;
    double result = (phat + z * z / (2 * totalScores) - z * Math.Sqrt((phat * (1 - phat) + z * z / (4 * totalScores)) / totalScores)) / (1 + z * z / totalScores);
    return result;
}
```

Figure 4.17. Code-based Wilson lower bound score (Author)

- Higher bound score depicted in Figure 4.18

  $$(centre\_adjusted\_probability + z * adjusted\_standard\_deviation) / denominator$$

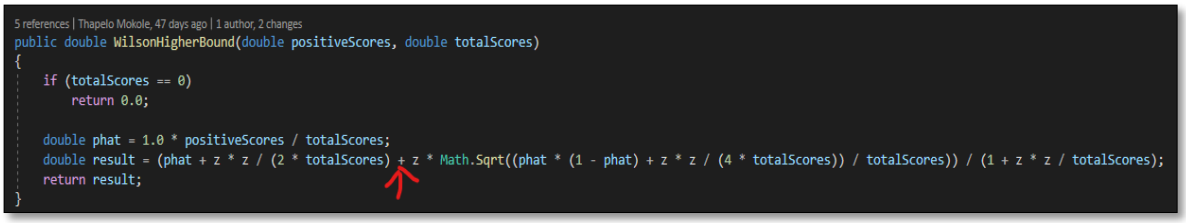


Figure 4.18. Code-based Wilson higher bound score (Author)

Example: 5-star scale

Table 4.7. Indicates the results of the Wilson score based on a 5-point scale (Author)

	Negative			Positive					Wilson score	
	1-Star	2-Star	3-Star	4-Star	5-Star	Total	Positive score	Negative score	Lower	Higher
Supervisor1	10	10	10	10	10	50	20	30	0.28	0.54
Supervisor2	100	100	200	300	300	1,000	600	400	0.57	0.63
Supervisor3	1000	1000	2500	5000	500	10,000	5,500	4,500	0.54	0.56

Using the Wilson score result set, there is a 95% probability that 28%–54% students may rate the supervisor well or have a positive sentiment towards the supervisor1. Approximately 57%–63% and 54%–56% may rate supervisor 2 and supervisor 3, respectively. The Wilson score uses data more efficiently, as it does not just combine or aggregate values into a simple statistical mean and standard error but uses data to determine the probability of a feature or function but in the positive light.

This then makes the Wilson score very useful for sorting to grasp which item is top-rated. Other uses of this can be to detect abuse, what percentage of students who work with a supervisor will mark them as abusive. The Wilson score can be used to create the “best in …” list to determine what percentage of students who interact with the supervisor will mark them as the “best in a particular subject.”

4.4.5.1 Adaptation of 7Cs to Algorithm

As indicated in the earlier chapters, the 7Cs framework will be used as the main driver of this study to cater to and understand how the supervisor performs under different categories of

supervision aspects. The student will be prompted with a questionnaire that holds 43 questions that reveal how the supervisor performs in different scenarios.

Table 4.8 provides a preview of how each question is posed and which category and indicator does it fall under. The indicator, in this case, represents the high-level intent that the question is aiming to prove, and the category is the family of association with regards to the 7Cs framework.

Table 4.8. A table indicating the questions posed in the ARI App (Author)

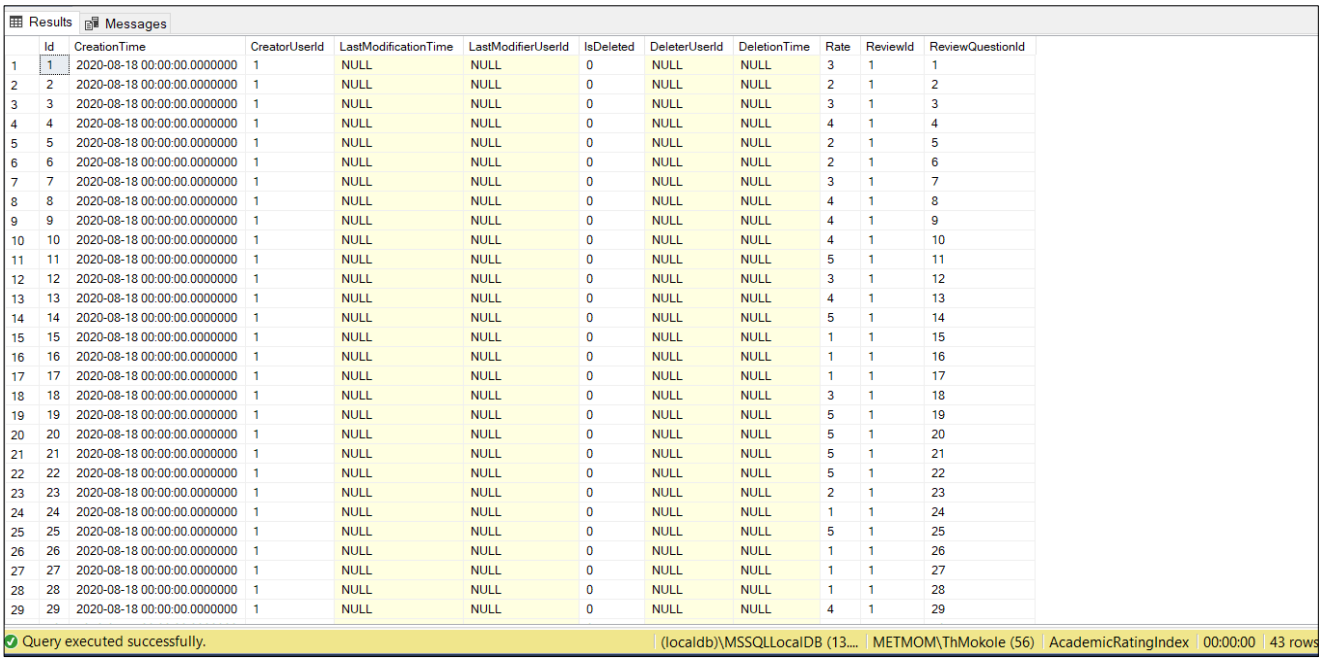
Category	Indicator	Sample Question
Care	Building relationships	Is the supervisor respectful, conscious, and reasonable with all students?
	Addressing learning needs	Does the supervisor maintain an intellectually and sincerely secure environment?
Captivate	Designing stimulating lessons	Does the supervisor plan lesson that are responsive to students' interests, backgrounds, and questions?
	Facilitating active participation	Does the supervisor make use of a variety of strategies for advancing interaction among students as they engage with thoughts and materials
Challenge	Pressing for rigorous thinking	Does the supervisor ask probing questions that require students to think outside of the box?
	Pressing for quality work	Does the supervisor require all students to endeavour for high-quality work and growth in their self-esteem?
	Pressing for persistence	Does the supervisor consistently require all students to engage, particularly those who may tend to be withdrawn?
Clarify	Explaining clearly	Does the supervisor effectively clarify key concepts and offers various examples for concepts that regularly cause a lack of certainty or confusion among the students?
	Checking for understanding	Does the supervisor regularly check for understanding utilising strategies such as asking questions, tests, and checking the students work?

	Providing constructive feedback	Does the supervisor provide specific, clear, brief input on the students' work in connection to the guidelines and built-up criteria for success?
Consolidate	Reviewing and summarising	Does the supervisor review and sum-up the discussion of the session and at the conclusion of each lesson, highlighting connections among thoughts?
	Connecting ideas	Does the supervisor explain associations between current and previous lessons, thoughts, and concepts?
Confer	Respecting perspectives	Does the supervisor and students work together to make learning conditions that invite and welcome different views and opinions?
	Promoting discussion	Does the supervisor provide frequent authentic openings for students to contribute thoughts and opinions as a portion of the supervision process?
	Inviting input	Does the supervisor give students a choice of deciding the perspectives of how they want to learn?
Control	Managing activities	Does the supervisor clarify, model, and actualise routines and methodologies to organise classroom processes?
	Managing behaviour	Does the supervisor clarify, model, and actualise routines and procedures that evoke positive student conduct?

The computational values are calculated in 3 segments in this project, firstly in the category level, then the indicator level, and the framework in its entirety level. The Wilson's score is calculated across the three defined phases. With each question with the potential of getting up to 5 points in the score, this project uses the Wilsons' lower bound score to get the confidence interval that defines a plausible range of values for the true mean given the observed values and the population.

Given that the students have answered all the 43 questions posed in the mobile application, the system will save all the 43 questions in the database. The system will then invoke the

calculations using the automated process. Figure 4.19 shows the 29 records of the 43 based on the student's feedback.



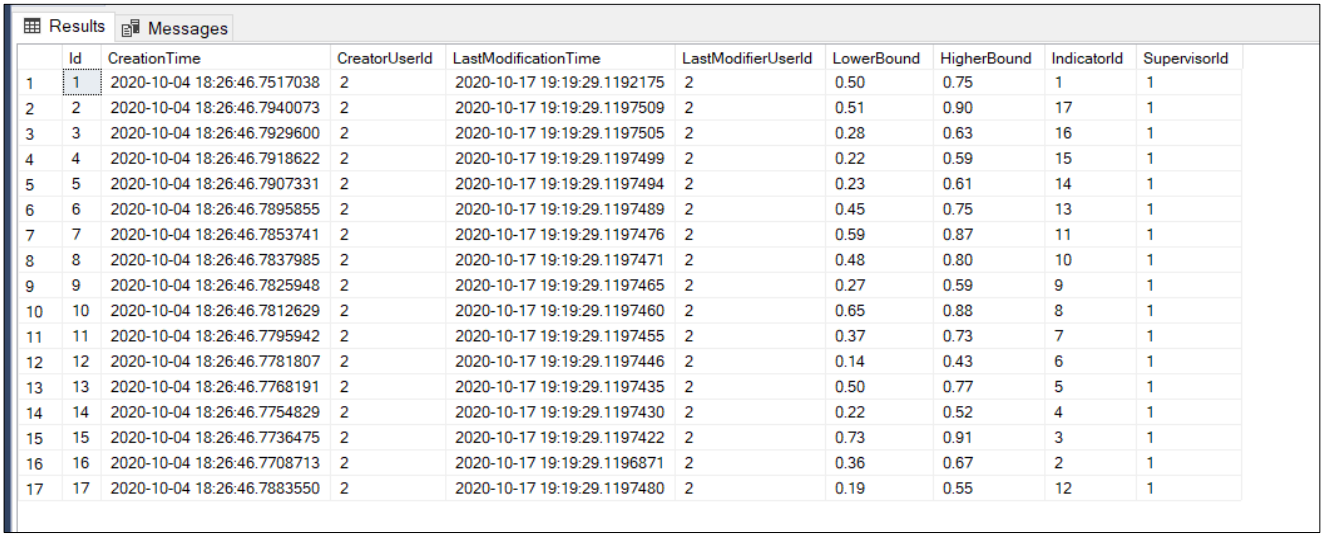
Results Messages

	Id	CreationTime	CreatorUserId	LastModificationTime	LastModifierUserId	IsDeleted	DeleterUserId	DeletionTime	Rate	ReviewId	ReviewQuestionId
1	1	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	3	1	1
2	2	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	2	1	2
3	3	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	3	1	3
4	4	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	4	1	4
5	5	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	2	1	5
6	6	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	2	1	6
7	7	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	3	1	7
8	8	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	4	1	8
9	9	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	4	1	9
10	10	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	4	1	10
11	11	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	5	1	11
12	12	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	3	1	12
13	13	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	4	1	13
14	14	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	5	1	14
15	15	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	1	1	15
16	16	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	1	1	16
17	17	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	1	1	17
18	18	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	3	1	18
19	19	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	5	1	19
20	20	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	5	1	20
21	21	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	5	1	21
22	22	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	5	1	22
23	23	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	2	1	23
24	24	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	1	1	24
25	25	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	5	1	25
26	26	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	1	1	26
27	27	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	1	1	27
28	28	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	1	1	28
29	29	2020-08-18 00:00:00.0000000	1	NULL	NULL	0	NULL	NULL	4	1	29

Query executed successfully. (localdb)\MSSQLLocalDB (13.... METMOM\ThMokole (56) AcademicRatingIndex 00:00:00 43 rows

Figure 4.19. The database result set of the review answers (Author)

Figure 4.20 shows the record standings after having invoked the algorithmic process applied on the indicator level based on the review's answers for a single supervisor.



Results Messages

	Id	CreationTime	CreatorUserId	LastModificationTime	LastModifierUserId	LowerBound	HigherBound	IndicatorId	SupervisorId
1	1	2020-10-04 18:26:46.7517038	2	2020-10-17 19:19:29.1192175	2	0.50	0.75	1	1
2	2	2020-10-04 18:26:46.7940073	2	2020-10-17 19:19:29.1197509	2	0.51	0.90	17	1
3	3	2020-10-04 18:26:46.7929600	2	2020-10-17 19:19:29.1197505	2	0.28	0.63	16	1
4	4	2020-10-04 18:26:46.7918622	2	2020-10-17 19:19:29.1197499	2	0.22	0.59	15	1
5	5	2020-10-04 18:26:46.7907331	2	2020-10-17 19:19:29.1197494	2	0.23	0.61	14	1
6	6	2020-10-04 18:26:46.7895855	2	2020-10-17 19:19:29.1197489	2	0.45	0.75	13	1
7	7	2020-10-04 18:26:46.7853741	2	2020-10-17 19:19:29.1197476	2	0.59	0.87	11	1
8	8	2020-10-04 18:26:46.7837985	2	2020-10-17 19:19:29.1197471	2	0.48	0.80	10	1
9	9	2020-10-04 18:26:46.7825948	2	2020-10-17 19:19:29.1197465	2	0.27	0.59	9	1
10	10	2020-10-04 18:26:46.7812629	2	2020-10-17 19:19:29.1197460	2	0.65	0.88	8	1
11	11	2020-10-04 18:26:46.7795942	2	2020-10-17 19:19:29.1197455	2	0.37	0.73	7	1
12	12	2020-10-04 18:26:46.7781807	2	2020-10-17 19:19:29.1197446	2	0.14	0.43	6	1
13	13	2020-10-04 18:26:46.7768191	2	2020-10-17 19:19:29.1197435	2	0.50	0.77	5	1
14	14	2020-10-04 18:26:46.7754829	2	2020-10-17 19:19:29.1197430	2	0.22	0.52	4	1
15	15	2020-10-04 18:26:46.7736475	2	2020-10-17 19:19:29.1197422	2	0.73	0.91	3	1
16	16	2020-10-04 18:26:46.7708713	2	2020-10-17 19:19:29.1196871	2	0.36	0.67	2	1
17	17	2020-10-04 18:26:46.7883550	2	2020-10-17 19:19:29.1197480	2	0.19	0.55	12	1

Figure 4.20. Database view of the Wilson score grouped by indicator (Author)

The code snippet in Figure 4.21 depicts an overview of how the Wilson score is calculated based on the indicator. The system first groups the answers by indicator and then sums the

values based on the rating. A rating between 0 and 3 is classified as a negative review, and a rating from 4 to 5 is classified as a positive rating. The system then proceeds to calculate the Wilson score on the indicator level using the positive accumulative value.

```
1 reference | Thapelo Mokole, 50 days ago | 1 author, 3 changes
private void RatingScoreInidicatorLevel(int SupervisorId)
{
    var indicators = _indicatorRepository.GetAllList();
    foreach (var indicator in indicators)
    {
        var _indicatorAnswers = _reviewAnswerRepository.GetAllList(x => x.ReviewFk.SupervisorId == SupervisorId && x.ReviewQuestionFk.IndicatorId == indicator.Id);

        int[] supervisorRatingArray = new int[5]; //An Array to hold each star out of 5... [1 through 5]

        var neg = _indicatorAnswers.Where(x => (x.Rate >= 0 && x.Rate <= 3)).Sum(z => z.Rate);
        var pos = _indicatorAnswers.Where(x => (x.Rate >= 4 && x.Rate <= 5)).Sum(z => z.Rate);
        var total = _indicatorAnswers.Sum(x => x.Rate);

        WilsonScoreInterval wilsonScoreInterval = new WilsonScoreInterval();
        var LowerBound = (decimal)wilsonScoreInterval.WilsonLowerBound(pos, total);
        var HigherBound = (decimal)wilsonScoreInterval.WilsonHigherBound(pos, total);

        var exists = _ratingScoreIndicatorRepository.FirstOrDefault(x => x.SupervisorId == SupervisorId && x.IndicatorId == indicator.Id);

        if (exists != null)
        {
            exists.HigherBound = HigherBound;
            exists.LowerBound = LowerBound;
            _ratingScoreIndicatorRepository.Update(exists);
        }
        else
        {
            var ratingScoreIndicator = new RatingScoreIndicator
            {
                HigherBound = HigherBound,
                LowerBound = LowerBound,
                SupervisorId = SupervisorId,
                IndicatorId = indicator.Id,
            };
            _ratingScoreIndicatorRepository.Insert(ratingScoreIndicator);
        }
    }
}
```

Figure 4.21. Wilson score by Indicator code snippet (Author)

The calculation in Figure 4.21 reveals how the records are stored at the category level once the algorithm has been applied to the review answers collection for a single supervisor. Figure 4.22 provides a view of the supervisor's database records based on the category after calculating the scores.

Results | Messages

	Id	CreationTime	CreatorUserId	LastModificationTime	LastModifierUserId	LowerBound	HigherBound	CategoryId	SupervisorId
1	1	2020-10-04 18:26:46.8484425	2	2020-10-17 19:19:29.1197914	2	0.41	0.60	6	1
2	2	2020-10-04 18:26:46.8469761	2	2020-10-17 19:19:29.1197909	2	0.46	0.71	5	1
3	3	2020-10-04 18:26:46.8458555	2	2020-10-17 19:19:29.1197904	2	0.55	0.73	4	1
4	4	2020-10-04 18:26:46.8443375	2	2020-10-17 19:19:29.1197897	2	0.55	0.74	3	1
5	5	2020-10-04 18:26:46.8429986	2	2020-10-17 19:19:29.1197591	2	0.39	0.60	2	1
6	6	2020-10-04 18:26:46.8282225	2	2020-10-17 19:19:29.1197517	2	0.48	0.68	1	1
7	7	2020-10-04 18:26:46.8495314	2	2020-10-17 19:19:29.1197920	2	0.41	0.70	7	1

Figure 4.22. Database view of the Wilson score grouped by category (Author)

Similar to the indicator level, the system groups the collection of review answers for a supervisor and then groups it by the category type. Figure 4.23 indicates that is achieved in

terms of code. Review answers between 0 and 3 are classified as a negative rating, and 4 to 5 is seen as a positive rating. The collective sum of classifications gets used to calculate the Wilson's score.

```
1 reference | Thapelo Mokole, 50 days ago | 1 author, 3 changes
private void RatingScoreCategoryLevel(int SupervisorId)
{
    var categories = _categoryRepository.GetAllList();

    foreach (var category in categories)
    {
        var _answersByCategory = _reviewAnswerRepository.GetAllList(x => x.ReviewFk.SupervisorId == SupervisorId && x.ReviewQuestionFk.IndicatorFk.CategoryId

        int[] supervisorRatingArray = new int[5]; //An Array to hold each star out of 5... [1 through 5]

        var neg = _answersByCategory.Where(x => (x.Rate >= 0 && x.Rate <= 3)).Sum(z => z.Rate);
        var pos = _answersByCategory.Where(x => (x.Rate >= 4 && x.Rate <= 5)).Sum(z => z.Rate);
        var total = _answersByCategory.Sum(x => x.Rate);

        WilsonScoreInterval wilsonScoreInterval = new WilsonScoreInterval();
        var LowerBound = (decimal)wilsonScoreInterval.WilsonLowerBound(pos, total);
        var HigherBound = (decimal)wilsonScoreInterval.WilsonHigherBound(pos, total);

        var exists = _ratingScoreCategoryRepository.FirstOrDefault(x => x.SupervisorId == SupervisorId && x.CategoryId == category.Id);
        if (exists != null)
        {
            exists.HigherBound = HigherBound;
            exists.LowerBound = LowerBound;
            _ratingScoreCategoryRepository.Update(exists);
        }
        else
        {
            var ratingScoreCategory = new RatingScoreCategory
            {
                HigherBound = HigherBound,
                LowerBound = LowerBound,
                SupervisorId = SupervisorId,
                CategoryId = category.Id
            };
            _ratingScoreCategoryRepository.Insert(ratingScoreCategory);
        }
    }
}
```

Figure 4.23. Wilson score by category code snippet (Author)

As a final stage, the system then applies the algorithm on the framework level, where it only looks at the collective review answers for a supervisor without grouping. Like the instances above, the negative and positive collective sums are gathered and used to calculate the global Wilson's score values. Figure 4.24 depicts the final stage of calculating ARI and of how the data is saved.

Results | Messages

	Id	CreationTime	CreatorUserId	ARIScore	ARI10Score	WilsonLowerBound	WilsonHigherBound	BayesianAverage	LaxoScore	ArithmeticMean	CumulativeRating	GranularityLevel	SupervisorId
1	1	2020-10-04 18:26:46.8633243	2	1.00	0.00	0.54	0.62	0.00	0.00			0	1

Figure 4.24. Database view of the final score at framework level (Author)

4.4.5.2 Computing the ARI

The ARI is calculated based on the supervisor's collective reviews and the output results of the global Wilsons score. The computation is based on each review's collective sum, which

amounts to a Wilson's score that is above or equal to 0.60 (60%) for the lower bound interval value equates to a single (1) ARI. Meaning for any review equal to or above a sum of 60% after the algorithm has been applied to it equates to 1-point ARI. Figures 4.25 and 4.26 give an overview of the process flow and logic control of the algorithm.

The ARI10, on the other hand, is calculated based on the reviews accumulated per institution. If a supervisor has amassed 10 reviews that are >= 60% in Wilson's score per institution, that accounts for a single (1) ARI10 index value. Meaning for every 10 reviews that are amassed per institution, the supervisor's score will increment by a single value.

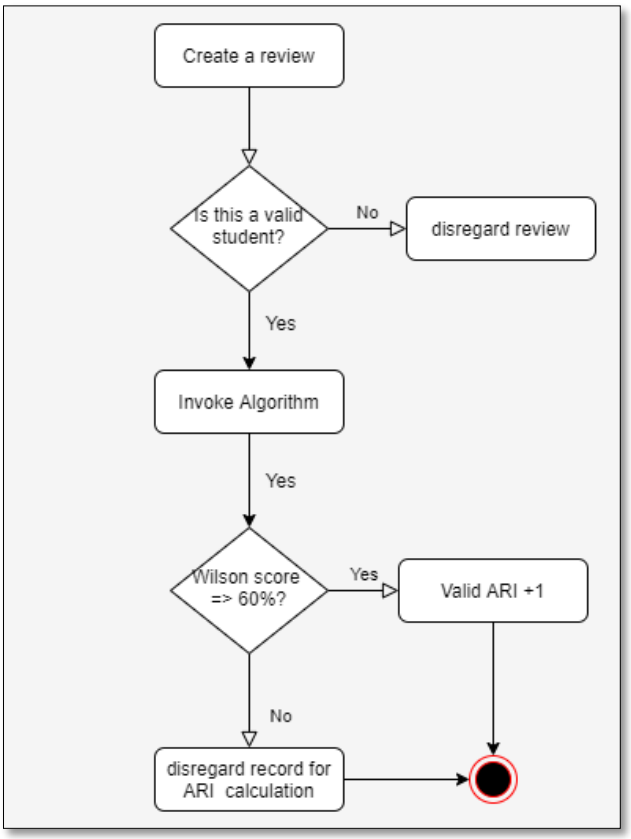


Figure 4.25. ARI computation process flow (Author)

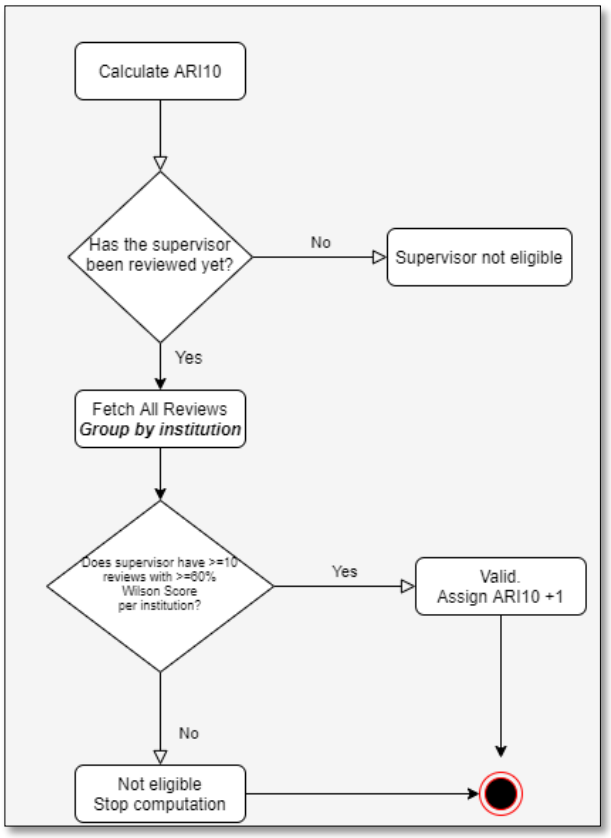


Figure 4.26. ARI10 computational process flow (Author)

Saving the records in the rating table, the ARI only gets incremented when the Wilson Score for each review is above the 60%. The ARI10 only gets incremented when the Wilson Score of 10 reviews is above 60% per institution rate.

Results | Messages

	Id	CreationTime	CreatorUserId	ARIScore	ARI10Score	WilsonLowerBound	WilsonHigherBound	BayesianAverage	LaxoScore	ArithmeticMean
1	1	2020-10-04 18:26:46.8633243	2	1.00	0.00	0.54	0.62	0.00	0.00	

Figure 4.27. Database view of the score and rating database table (Author)

4.4.6 Sentiment analysis

Sentiment analysis alludes to the handling of natural language processing to decide if a piece of text contains emotional data and the sort of abstract information it communicates (Soleymani et al., 2017; Zhang et al., 2018). The subjective information expressed speaks to the demeanour behind the content either negative, positive, or neutral. Using natural language processing techniques, behavioural context can be extracted from a collection of words, documents, or sentences, and accurately classify it (Mokole & Roderick, 2019). The study used open-source 3rd party code base, a sentiment analysis tool called Valence Aware Dictionary and Sentiment Reasoner prefixed as VADER. A vocabulary and rule-based estimation examination tool that is explicitly sensitive to assumptions communicated in social media (vaderSentiment, 2020). Based on the students' remarks or comments made at the end of the review, the system applies the text to the sentiment analysis process. Figure 4.28 provides an overview of the input and output for sentiments analysis.

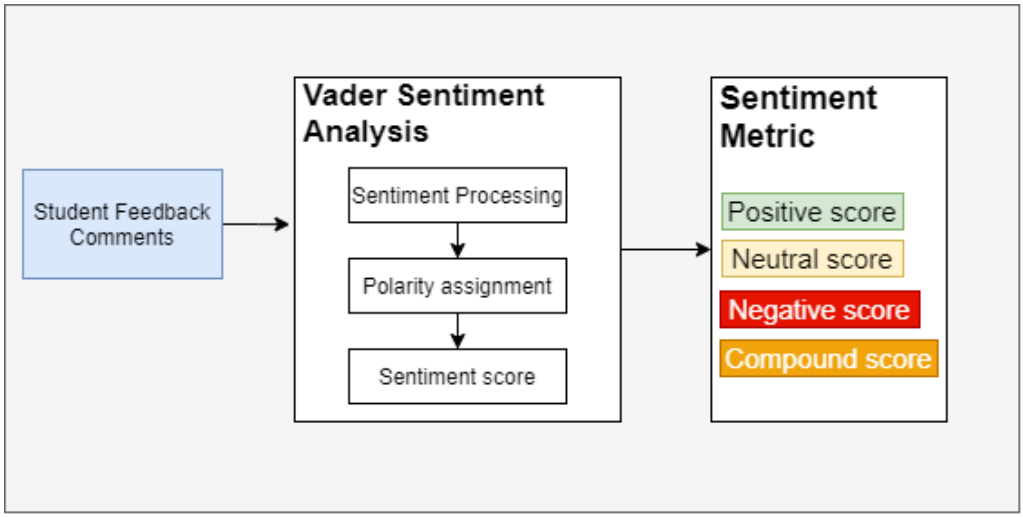


Figure 4.28. Sentiment analysis diagram (Author)

In the creators' words (vaderSentiment, 2020) of the algorithm, words have been trained and classified. As a result, one of the metric outputs is a value called compound, and is defined as follows:

> *"The score is computed by summing the valence scores of each word in the lexicon, adjusted according to the rules, and then normalised to be between -1 (most extreme negative) and +1 (most extreme positive). This is the most useful metric for achieving a single unidimensional measure of sentiment for a given sentence. Calling it a 'normalised, weighted composite score' is accurate" (vaderSentiment, 2020).*

- A Compound score greater than or equal to +0.05 results in positive sentiment
- A Compound score greater than -0.05 and less than +0.05 results in neutral sentiment
- A Compound score less than or equal to -0.05 results in negative sentiment

4.4.7 Chapter summary

This chapter discussed a detailed account of system design and implementation of the ARI software development from gathering, architecture, design, implementation, and algorithms requirements. The 3rd party technological solutions and libraries used to bring together the working application were also show-cased to illustrate the framework and methodology that best suits the design and implementation of the study's objectives and how the different components integrate. This chapter also focused on the nature of the algorithm and how the 7Cs framework was adapted to the algorithm. In particular, the Wilson score interval is used to calculate a confident estimate about the actions or preferences of a general population, given a set of reviews made by students against a specific supervisor. The following chapter will cover the usability of and functional compatibility of the ARI system.

5 CHAPTER 5: SYSTEM TESTING AND RESULTS ANALYSIS

Software Quality Assurance (SQA) is a set of things to ensure quality in software program engineering processes (Mnkandla & Dwolatzky, 2006). It guarantees that the developed system meets and agrees with the pre-defined or normalised quality standards. SQA is an ongoing technique inside the Software Development Life Cycle (SDLC) that regularly checks the developed program to ensure it passes the ideal quality measures (Galin, 2014; Tinnaluri, 2016). Section 5.1 presents the various system testing types and techniques and the results thereof. Section 5.2 presents the achievements of the objectives as defined in earlier chapters, specifically section 1.4. Section 5.3 outlines the functional domain requirement outcomes as stipulated in section 2.6, and finally, Section 5.4 presents the summary of the chapter.

5.1 System Testing

Software testing can be broken into two categories: the functional and non-functional. Functional testing evaluates if a component or system satisfies functional requirements; hence, non-functional evaluates that a component or system complies with non-functional requirements (Kuester et al., 2010). This study followed software testing protocols in the agile community outlined by other scholars (Mnkandla & Dwolatzky, 2006; Sneha & Malle, 2017; Sethi, 2017). The following tests will be implemented for the functional testing, unlike machine learning algorithms that have options like the F1 score, Precision, and Recall measures to test the accuracy of the calculation (McNee et al., 2006; Sokolova et al., 2006). Other alternative such as the unit, sanity, integration, and usability testing, exist (Ghuman, 2014, Gyure, Hoover, 2018; Bühler & Wegener, 2008). For the non-functional test, user experience, storage, operational, security, and performance testing will be implemented (Afzal et al., 2008; Dave et al., 2018).

5.1.1 Smoke and Sanity Testing

Smoke testing is a test technique that gets executed after successful code compilation and the release thereof, to ensure the stability of the system from key features which can be referred to as spot checks (Chauhan, 2014). It is also called build verification testing. A smoke test is a series of test-cases that are run before initiating with full-scale testing of an application (Gupta & Saxena, 2013). Sanity testing, usually done after a smoke test, ensures that all the major

and vital functionalities of the application/system are working correctly (Hooda & Chhillar, 2015). Hooda and Chhillar (2015) further say that smoke and sanity testing are performed to ensure all links and features are working and the environment is stable. The following are the main aims of the smoke and sanity testing: to minimise integration risk, reduce the risk of low quality, and support easier bug diagnosis (Hooda & Chhillar, 2015; Memon, A.M. & Xie, Q., 2004; Jamil, 2016).

Since this study focuses on following the computer lab-based testing, Table 5.1 indicates whether the test was satisfactory. From Table 5.1, it is clear that the smoke testing process outcomes, which is 10/11 or 91% of the touchpoints, were satisfactory.

Table 5.1. Smoke testing results (Testing Checklist, 2021)

Name	**Outcome Satisfactory**	**Solutions**
General Test		
Changes are documented and should contain the following details • The release version • Comparison list showcasing the current and former release builds • The discrepancies that were altered • The software changes that have been brought forth as change requests and have been successfully implemented • The discrepancies that are known and have not been fixed with pre-defined work arounds to them	Yes	This was a continuous process that resulted in trial and error
Steps that detail how to install the product	Yes	
System guidelines for the user	Yes	
The functional and non-functional testing outcomes of the various testing phases	No	
Historical release documents for the various testing cycles	Yes	The android store allows one to indicate the features in the release
The application can be opened without failing or crushing	Yes	
The application allows the clients/users access	Yes	
The application allows the user to execute basic functionality like navigation without breaking or crushing	Yes	Roles and permissions drive the application. Based on the permissions the user can navigate accordingly
The newly created features function correctly as expected	Yes	

The CRUD actions function as expected, meaning the user can create, update, and delete records without crushing the application	Yes	
The application allows for multiprocessing with navigational ease between different applications/systems without crushing	Yes	Audit logging functionality present in case such were to happen
Quick Scan Tests		
The basic flow of functionality can happen without crushing or Automated scans can be executed without any discrepancies or functional failure to the system	Yes	

Table 5.2 essentially displays the sanity testing results, categorised into the general, logical, physical, and automation testing with a satisfactory level of 5/6 (83%) items for the general attribute's tests, and the logical tests amounting to 6/8 (75%). The physical tests results show a score of 5/7 (71%) and the automation tests being 0% because no automation tests were conducted in this study in line with the sanity testing approach. An overall percentage of 62% is satisfactory for the sanity testing technique.

Table 5.2. Sanity testing results (Testing Checklist, 2021)

Name	**Outcome Satisfactory**
Sanity General Tests	
The functionality that will be under scrutiny and the procedures thereof and their rationality are adequately described	Yes
The functionality and the procedures thereof and their rationality agree with the anticipated objective	Yes
All the attributes/characteristics of important quality have been adequately dealt with	Yes
The result of the risk analysis is identifiable in the test plan	Yes
Test results from the previous testing-cycle are accessible and to give an understanding of the nature of the tests	No
Discrepancies that were found after the last time the test product was utilised are accessible and show on what focuses the coverage of the test ware is inadequate	Yes
Sanity Logical Tests	
Logical tests are based on a clearly defined test basis	Yes
No major outstanding issues are found the defined design and the logical tests are relevant	Yes
The test design structure is clearly defined	Yes
Specification elements can be used to trace the logical tests to ensure that the changes are implemented correctly	Yes

Risk category are defined and help trace the logical tests to ensure changes are implemented correctly	No
Logical tests are created on the basis of the test techniques	No
Test techniques are implemented effectively and efficiently when the need arises	Yes
Any changes that occurred in the logical test design can be indicated (i.e. Changing from one technique of testing to another)	No
Sanity Physical Tests	
The test environment on which the physical scenarios is based on are specified	Yes
No major test base issues are remaining, and the physical test design are kept up to date	Yes
The test design structure is clearly defined	Yes
Specification elements can be used to trace the physical tests to ensure that the changes are implemented correctly	Yes
Risk category are defined and help trace the physical tests to ensure changes are implemented correctly	No
The physical tests can be tied back to the logical tests that share the same goal	No
The physical test scenarios are defined on the test based	Yes
Sanity Test tooling (automation)	
The test base on which the automation is based on is clearly demonstrated	No
The automation is exceptional, there are no major extraordinary issues in the plan specified in the test base	No
There are errors in the tooling, and they have a clear status. It very well may be assessed which bug fixes/changes should be performed on the automation-tools	No
Documentation for the automation mechanism is accessible, so changes can be proficiently executed on it when the need arises.	No
The physical architecture of the automation system, can be tested for integrity before that actual automation tests kick off	No

5.1.2 Usability Testing

Usability testing speaks to the degree to which specified clients can use a product to attain the specified objectives with adequacy, proficiency, and fulfilment in a predefined context of use (Bevan et al., 2016). The product is exposed to the actual client in a pre-production environment where they test the product. The client's comfort is determined by the outcome of the testing cycle and by the criticism they express towards the product (Usability Testing, 2021). Furthermore, Bevan et al. (2016) say that usability testing is the effectiveness with which the system can function with the integral tasks inside the software, and whether there are any unnecessary boundaries which forestall them from doing so. Other scholars have defined the technique to assess a service by testing it with agent clients. It assists with

characterising client capacity to figure out how to work, plan contributions for, and decipher outputs of a framework or component (Petrie & Bevan, 2009; Kaikkonen *et al.*, 2005).

This study followed user testing as described by Bevan et al. (2016), which focused mainly on the integral tasks inside the software rather than targeted users. The testing produced a 100% satisfactory outcome of the test touchpoints. Table 5.3 shows the different items that were tested or invoked by this technique to ensure that the software product is understandable, effortless to learn, effortless to operate, and desirable to the client underneath the specified conditions.

Table 5.3. Usability testing results (Testing Checklist, 2021)

Name	**Outcome Satisfactory**
No spelling mistakes are available on the applications views	Yes
The font style is the same across the system	Yes
The text and labels are aligned uniformly system wide	Yes
No grammatical errors exist on the modals that present the error messages	Yes
Tool tips are made available when hoovering other fields	Yes
The fields are aligned properly system wide	Yes
Proper spacing is applied system wide for all field labels, error messages and tables	Yes
All buttons system wide has the same formatting properties (success, warn and danger)	Yes
The home link is visible and accessible to every navigational page	Yes
When disabled, fields are made grey to inform the user of their status	Yes
No broken links and figures exist system wide	Yes
Before deleting or updating a record, a modal is displayed to prompt the user for confirmation	Yes
The application is adaptable to different screen resolutions	Yes
The system runs efficiently and as effective as possible	Yes
Tabbing properties are working in the application	Yes
The vertical and horizontal scroll bars are displayed for lists or grid forms as required	Yes
All the field validations are in place to ensure that the user has filled all the required items before submitting	Yes
The title of the page is made visible on each page	Yes
The user can access the fields by just navigating using the keyboard instead of the mouse	Yes
The data in the dropdown does not get truncated if the text is too long for the field size, ensure wrapping is available for longer text labels	Yes

5.1.3 Database Testing

Database testing is a software technique for assessing the schema, tables, and triggers of the Database. It additionally examines the data integrity and consistency. It may also create complicated queries targeted at performance to understand the database and test its responsiveness (Database Testing, 2021). Kaur and Sehra (2015) state that database testing is the execution of assessments to verify the exact data values from the database either using desktop-based software or web-based applications. Table 5.4 is designed to show the test cases that have been covered while testing the database with coverage of 22/24 (92%) satisfactory results and 2 test cases not executed due to the project's nature.

Table 5.4. Database testing results (Testing Checklist, 2021)

Name	**Outcome Satisfactory**
Check the database name: The name should coordinate with the one in the specifications	Yes
Ensure all the tables and field types coordinates with the specifications	Yes
Ensure if columns should be null	Yes
Ensure that each table has a primary key defined	Yes
Ensure all the stored-procs work and are accessible	Yes
Check if the stored-procs are accessible	Yes
Ensure the stored-proc names	Yes
Ensure that the input values have the same type as in the specification	Yes
Check if input values are required or optional	Yes
Check if the stored-proc works with missing input values	Yes
Ensure that when no records are returned, no actual records have been altered in the process	-
Create simple data query scripts in SQL	Yes
Ensure the stored-proc returns the specified set of records	Yes
Ensure the stored-procs works with random data	Yes
Ensure each table has a flag	Yes
Ensure that the data gets persisted from the client front-end	Yes
Ensure all the Data Manipulation actions can be invoked successfully	Yes
Ensure the SQL field properties matches with the front-end properties as well	Yes
Ensure all the various database environments have got unique names to distinguish each other	Yes
Ensure the database is encrypted to avoid data breaches	Yes
Check the latency of each transaction when getting data from SQL.	Yes
Ensure that the records stored in the database are a direct mirror of what is displayed in the front-end	Yes
Ensure all the insert statements work correctly on all the defined tables	Yes

Ensure that the database triggers are actionable	-

5.1.4 Security Testing

Security testing ensures the data framework secures information and keeps up functionality as expected. Penetration testing and weakness testing also known as vulnerability testing are the other forms of security testing (Austin et al., 2013). Security testing is a non-functional testing technique used to determine a data system's safety mechanism to protect its information and ensure that the performance is not compromised and works as intended (Security Testing, 2021). Potter and McGraw (2004) state that security testing is about making software behave efficiently in the presence of a malicious attack, even though software failures usually occur spontaneously in the real world. In Table 5.5, the test cases that ensure the ARI system is secure with various technologies are implemented and provided for by aspnetboilerplate (Technology, 2020). The results show satisfactory outcome level of the testing should be 100% to ensure that the client's information is safe.

Table 5.5. security testing results (Testing Checklist, 2021)

Name	**Outcome Satisfactory**
Ensure all the sensitive data gets transmitted over the line using a secure connection (HTTPS).	Yes
Ensure that all vital data like identity numbers, passwords and addresses are encrypted	Yes
Ensure that proper password strength methods are implemented on sign-up, change password, and forgot password screens.	Yes
Ensure that after altering a password, the client cannot reauthenticate with the previous one.	Yes
Ensure that no sensitive data is displayed in the error messages.	Yes
Ensure that when the client's session has expired the client cannot navigate the site and should be prompted to re-authenticate into the system.	Yes
Ensure that access to critical pages required the client to the authenticated and authorised.	Yes
Ensure that the "View Source code" is not available to be used in production, production build should not have debug ability.	Yes
Ensure that the user profiles get locked after several incorrect attempts.	Yes
Ensure that no cookies or sessions have passwords stored in them.	Yes
Ensure that the system displays an error if the database is down and no transactions can take place.	Yes
Ensure that SQL injection can be prevented	Yes

Ensure that permissions and organisational groups are set in place to restrict access to unauthorised pages.	Yes
Ensure that audit logging is actioned for vital processes.	Yes
Ensure that cookies and tokens are encrypted when viewed on the address bar.	Yes
Ensure all tokens are encrypted when being stored	Yes

5.2 Achievements of Objectives

This study aimed to address the three objectives: 1) develop an algorithm for supervision quality measure based on the Wilson score interval; 2) compile a cross-platform relational database to store the data, and 3) compute and standardise the application for suitability into different learning environments based on the 7Cs framework. Using C# programming language as a base for the business logic and Microsoft Azure SQL database as a storage place for data, this section discusses how the study met the defined objectives.

5.2.1 Develop an algorithm

The algorithm was developed using the C# programming language with the aid of ASP.NET Boilerplate applications (Technology, 2020). It was developed to adhere to the principles of the Nlayer-Architecture. As the main driver of the computation, the Wilson score interval was used to calculate the results of the review made by the student while answering 43 categorical questions. In this study, the Wilson score interval uses the z-score of 1.96 (Colan, 2013), which translates to a confidence level of 95%. This confidence level estimate provides a useful representation whenever one wants to estimate a general population's action or preferences. This then reflects the degree of sentiment the population has towards the subject under scrutiny in line with the observation of previous scholars (Shan, 2020; Nair et al., 2020). The study used 43 questions classified by category and indicator. The Wilson score gets calculated on each level to see how the supervisor is scored according to the student's perspective. The application is hosted on the Microsoft Azure cloud platform and it is available and accessible through the Internet.

Table 5.6 shows the overall process followed in trying to meet this objective.

Table 5.6. Objective 1 achievement outcome (Author)

Objective	Develop an algorithm to measure academic supervision quality, using the Wilson score interval to get a confident estimate about students' actions or preferences in general towards a supervisor.
Question	How can the Wilson score interval be optimised into a software algorithm?
Solution	
Outcome	Fulfilled
Outcome Process	Having collected the review score from a 5-point Likert scale in the mobile app, the system then invokes the rating calculation using the Wilson Score interval. Using the lower bound score, the system can then allocate a rating/index that is impartial to a supervisor.

5.2.2 Standardise the Application

The application was standardised using the 7Cs framework to have questions that are neutral to any institution. The 7Cs framework has key components for effective teaching and has assessment tools for measuring beyond tertiary institutions to include what teachers do in their classrooms (Ferguson & Danielson, 2015). School systems are increasingly incorporating the scholars' view of the teaching adequacy from the perspective of the instructor's accountability systems. Using the 7Cs framework of teaching effectiveness brings to light the key problems in validating students grasp of information and the relationship they have with the institution's representative of learning and teaching (Phillips at el., 2021).

The 7Cs frameworks help to build relationships, address learning needs, design stimulating lessons, facilitate active participation, press for rigorous thinking, good quality work, and persistence. The framework also provides a clear explanation, understanding, constructive feedback, reviews, provide summaries, connects ideas, promotes discussion, invites input, managing activities, and helping in managing behaviour (Tripod Education Partners, 2015). These points are essential to this study to ensure that the application is suitable for different learning environments. Table 5.7 displays the entire process in addressing the objectives.

Table 5.7. Objective 2 achievement outcome (Author)

Objective	Compute and standardise the application to be suitable for different learning environments. The 7Cs framework will be used to examine key issues in validating the student's perception of their supervisor

Question	What level of abstraction will be implemented to ensure that the 7Cs framework can be adapted in different learning/academic environments?
Solution	
Outcome	Fulfilled
Outcome Process	Using the 7Cs framework, this study has invoked a questionnaire based on static questions aimed at revealing a student's sentiment on the supervisor. These questions are grouped first by category and then by the indicator. The questions are generated and created so that they can be changed from being directed to a supervisor to a teacher, lecture, or instructor.

5.2.3 Compile a relational database

Among various databases available, Microsoft Azure SQL was used to develop the relational entities (Roy-Hubara et al., 2019). Because Microsoft Azure SQL is a cloud-hosted database, it handles features such as scalability, backup, and high availability of the database (Antonopoulos et al, 2020). There are many advantages of using Microsoft Azure SQL as the main storehouse of records: no physical hardware required, affordability, sync and migration, data-loss prevention, and intelligent protection are all features that come with it (Mauri et al., 2020; Lobel & Boyd, 2014). If an application is hosted on a Microsoft cloud platform, the database should also be hosted in the same ecosystem to accommodate the advantages listed above. The database was created to a count of 73 tables that are interconnected through foreign key properties, and the tables are grouped using the following schemas.

- 31 system-specific tables to manage the roles, permissions, auditing, tenants, organisational groups, and all system-related stats.
- 11 Hangfire tables, to save all the background processing tasks such as email sending, algorithm processing, and all other tasks that can be scheduled and processed automatically.
- 30 ARI-specific features tables to maintain reviews, students, supervisors, and all other features defined in the study.
- 1 Entity framework migration history table.

Table 5.8 shows us the overall process in trying to meet this objective.

Table 5.8. Objective 3 achievement outcome (Author)

Objective	Compile a cross-platform relational database to store the data.

Question	How will the database entities be mapped to one another in a relational manner?
Solution	
Outcome	Fulfilled
Outcome Process	This objective was implemented using Azure Microsoft SQL, which is a relational database. The technology was accessed using the Microsoft Azure students profile edition provided for by the university

5.3 Functional Requirements Domain Outcomes

This section will overview the test results obtained in the software development lifecycle to ensure that defined objectives are met. These are the ARI components that are defined in the previous chapters (4.3.1): the supervisor, student, rating engine, on-site administrator, and the central-university verification domain. The outcome of the functionality is presented in Table 5.9; it represents each domain of the ARI. Requirements gathering needs a granular stage of requirement specifications with key objectives, purpose or sketches that depicts the need (Shah & Patel, 2016). Below are several tables that highlight the predefined requirement, purpose, and the outcome of the study, including if the requirement has been met. The overall pass or fail criteria will be based on accuracy, validity, timing, and capacity limits.

The first table shows the supervisor domain (Table 5.9). It is mainly guided to ensure that the supervisor can perform functions like view his or her reviews, engage with students and see their personal report. From Table 5.9, a 100% pass outcome in the defined requirements is observed.

Table 5.9. Supervisor domain test cases outcome (Author)

Functions	Purpose	Outcome
View reviews against his or her name.	Be aware of the incidents raised against them, lest their reputation be ruined.	Pass
Respond and resolve the problems addressed in the review.	To show enthusiasm and keenness to address the issues raised.	Pass
Maintain improve the supervisors ARI.	Ensure that one can raise the ranks and be deemed as a credible supervisor.	Pass
Able to maintain and upkeep their user profile.	To ensure safety and security.	Pass
Get a report on the ratings they have received.	To see a trend line report of the progress of themselves.	Pass

Raise tickets for fraudulent behaviour if they suspect malicious activity against their name or account.	To prevent fraud.	Pass
Verify profile accounts.	To avoid impersonation and identity fraud.	Pass

Following the supervisor domain is the students-domain. From the defined requirements, 4/5 (80%) have been met, with only one that is outstanding being the ability to escalate issues to high authorities. Overall, the main features of the requirements have been met, a platform where students can voice their thought on the outcomes of being supervised.

Table 5.10. Student domain test cases outcome (Author)

Functions	Purpose	Outcome
Create an account or profile	Ensure that a valid student is validated against the institutions/universities' central database.	Pass
Create, Update and Remove reviews	The main activity to be fulfilled in the user	Pass
Search for a supervisor.	Allow the supervisee to locate the correct supervisor they to rate.	Pass
Engage in forum	Here students can put their issue publicly and discuss with each other.	Pass
Student Relationship management	Allow putting their problems in front of higher authority by leaving the message to them, and the authority can reply or resolve the solution and give a quick reply to the students.	N/A (Feature is left for future development)

Another domain whose outcome was observed is the rating processing engine domain, which seeks to invoke the algorithm's computations based on the reviews made by a student for a supervisor. The main feature is that the computation must deliver an impartial and dependable score for all supervisors. As a result, 4/5 (80%) of the defined requirements have been met only to the exception of sending out notifications to both students and supervisors on the activities of the system.

Table 5.11. Rating Processing Engine domain test cases outcome (Author)

Functions	Purpose	Outcome
Aggregate the reviews into an ARI	To enable the supervisor to be aware of their score.	Pass
A dependable, impartial, clear, transparent, current, and fair score	To avoid unfairness and criminality	Pass

Liaise with the universities central database to only allow valid students to do reviews	To ensure that only legitimate students partake in the reviewing process	Pass
Schedule support tasks and bulk-processing capabilities, also monitoring the results and guarantee task-processing is completed within the specified service level agreement.	To provide monitoring measurements, among others network bandwidth usages, processing capacity, and disk space utilisation.	Pass
Send out notifications.	Push notifications are micro-texts that can reach a subscribed audience, with the intent of delivering a message.	N/A (Feature is left for future development)

Table 5.12 represents the on-premise administration domain, which is designed to serve as a window of administration-related tasks such as ensuring that the students are real and have been verified. With this domain, administrators can dictate who has access to the platform and disable malicious users. A total of 4/7 (57%) of the defined outcomes have been met. Escalations and notifications remain the outstanding feature that must be met, with that students and supervisors will be able to raise concerns and difficulties faced. This study will address the missing requirements in future enhancement releases.

Table 5.12. On-Premise Administration domain test cases outcome (Author)

Functions	Purpose	Outcome
Raise internal inquiries on what appears to be fraudulent reviews.	Provide a clear consulting communication channel.	N/A (Feature is left for future development)
Provide reports and system health-checks to ensure a fair index	Provide application performance information and participate in periodic support compliance audits	Pass
Administer system-wide stability	Keeping track of the online systems, and support of 3rd party systems and data on all environments of deployment	Pass
Create, escalate, and enquire Operational Incidents in accordance with the organisation's incident management policies and procedures. Ensuring that the tickets can be traced.	Perform proactive analysis of failures and patterns on 3rd party systems and data to make strides in enhancing service quality	N/A (Feature is left for future development)
Always guarantee precise and ideal updates to Incidents. Guarantee the correspondence of Incidents and status updates are of great-standard and contain precise and exceptional data	Ensure service is provided within customer Service level Agreements, Management of appropriate processes maintaining and supporting incoming incidents and requests.	N/A (Feature is left for future development)
Provide the proposed system with valid students to minimise fraudulent behaviour, thereby producing an incorrect ARI.	Notify supervisors in the correct manner and time of any incident detected that impact the supervisor credibility, provide info, distribute, and present incident reports to a predefined list of supervisors.	Pass
Perform real-time monitoring of vital TIC connections	Comply with the business footprint shift requirements of the support team	Pass

Finally, the university's central verification domain ensures that the students who are making reviews have been verified by the institution as valid and enrolled students. This feature and domain will help with accountability in that the system will have limited malicious users who want to tarnish the name of a supervisor. Overall, 0/3 (0%) requirements have been met in this domain because this will require the actual connection to known or registered institutions. This study will address the missing requirements in future enhancement releases.

Table 5.13. Universities central verification domain test cases outcome (Author)

Functions	Purpose	Outcome
Student Information System	Maintaining an actual record of every one of the students is helpful for organisation purposes as is storing that data for ease of access by ARIs	N/A (Feature is left for future development)
Student Searching	Offer simple to-utilise search and sort features making it simple for clients to locate a particular student in the data set through an API	N/A (Feature is left for future development)
Student Reporting	Reporting harmful content and behaviour from students enrolled with the Institution	N/A (Feature is left for future development)

5.4 Chapter Summary

This chapter presented the results of the various testing disciplines available in the system development life cycle. Both functional and non-functional tests were invoked to ensure that the research outcomes are achieved. The outcome of each test process seems to suggest an acceptance of the correlation between what was expected and what was produced in the entire process. Furthermore, the chapter show-cased the predefined objectives and their outcome, including if the goal was achieved or not, and the rate at which each objective was achieved in the process. Chapter 6 will discuss the future recommendations and features of the study by also proving ways of improvement and concluding the study.

6 CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

This chapter provides a detailed summary of the research work, recommendations for future work, and the limitations of the current scope. The conclusion highlights the key focus of the study, the basic highlights of the research plan, and the critical results of the ARI. Specifically, the chapter shows the degree to which the points have been accomplished while outlining the key discoveries and results. Recommendations are based on the study's limitations and the result of the system testing discussed in the earlier chapter.

6.1 Overview

This study's main aim was to develop an academic staff rating index system as an indicator of academic service quality, which can, in turn, contribute towards improving the relationship between the supervisor and the student. The ARI results will provide crucial insights to determine strengths, weaknesses, and improvements for the supervisor. To meet this expectation, the study created an application ecosystem comprising of the API, web application and mobile application for the following reasons:

- API is used to handle the business logic and to orchestrate the functions of the ecosystem. Serving as the engine, the API works as a glue between the database and the client-facing applications.
- Web application is used to handle client-facing requests and to work as an administrative portal. It is used to allow administrators to see the number of new users, roles and permissions, and all system-related issues.
- Mobile application is used as a platform of interaction between the student and the supervisor. The mobile application serves as an avenue for the collection of ratings and reviews. From the mobile application, the student can create, update, and delete reviews against a supervisor, and the supervisor can see their ratings and cumulative score.

As the driver of the review, this study has used the 7Cs framework to measure academic quality, due to its multi-faceted questions that are aimed at revealing character and level of ability. By using the 7Cs framework, this study can showcase areas of improvement that the supervisor might have. It helps an academic institution to scale and properly allocate its

resources based on its core-abilities and strengths, thereby gaining ground and better throughput in students.

The study implemented the Wilson score interval used to determine the confidence interval for a proportion in a statistical population. Wilson's score helped ensure that the ARI scores' computations are aggregated using established methods and to provide a dependable and impartial score. As such, the study achieved a confident estimate about the actions or preferences of a general population or sample of data by assigning scores for ranking the supervisor's reviews.

Using Microsoft Azure cloud services and the Google play store, this study has published the apps to the following links.

Requires admin credentials to gain access to the content

API: https://academicratingindex.azurewebsites.net

Web: https://academicratingindex-web.azurewebsites.net/account/login

Students and Supervisors can register and create accounts

App: https://play.google.com/store/apps/details?id=za.ac.unisa.marcia.ari&hl=en_ZA

This study provides a platform for a core and wholesome online community that is aimed at respectfully expressing one's sentiment. Various platforms exist in the market for rating products and institutions. These include HelloPeter (Hellopeter, 2021), Capterra (Capterra, 2021) and TrustRadius (trustradius, 2021). However, these applications offer a platform where customers can express their sentiments and rate accordingly outside the academic scope. ARI serves to fulfil the gap by providing a platform for the academic audience. It is an application that is centralised and not favourable to any institution.

6.2 Recommendations

Whilst the study provide a good digital platform towards supervision service quality, it is acknowledged, however, that its impact to students and supervisor relationship has not been evaluated, also the student verification mechanism is yet to be implemented with the various academic institutions, to ensure that a student is verified and validated with a known academic institution before they can create reviews. Hence the recommendations for future studies is to test the ARI against real-live student, that can be authenticated against their intuitions list of

student records. The sentiments captured on the digital platform can serve as an avenue of expression and identify areas of improvement. Further, the study recommends evaluation of ARI diffusion using technology acceptance models. Published authors and supervisors can use ARI as an indicator of their supervision impact to complement a good citation index. The citation index focuses on the abstract aspect of academia, the ARI deals with the human aspect of academia.

6.3 Conclusion

The arrival of the Internet and digital forms of communication has resulted in further expansion of distance learning. This further led to the ability to examine the characteristics and challenges of distance learning and supervision in the literature. Although the literature points out challenges in both distance and campus context learning, the supervision quality issues are more prevalent in distance learning context. In distance learning institutions, student and supervisor face-to-face interaction is minimal and close to none in some instances. Supervision is a key factor in the progression of the institution, more specifically in this digital age. This study attempts to contribute towards service quality, especially for those distant learning institutions. The study developed a digital academic rating index (ARI) as a mobile and web application that can allow students to rate their supervisors in terms of the 7Cs framework.

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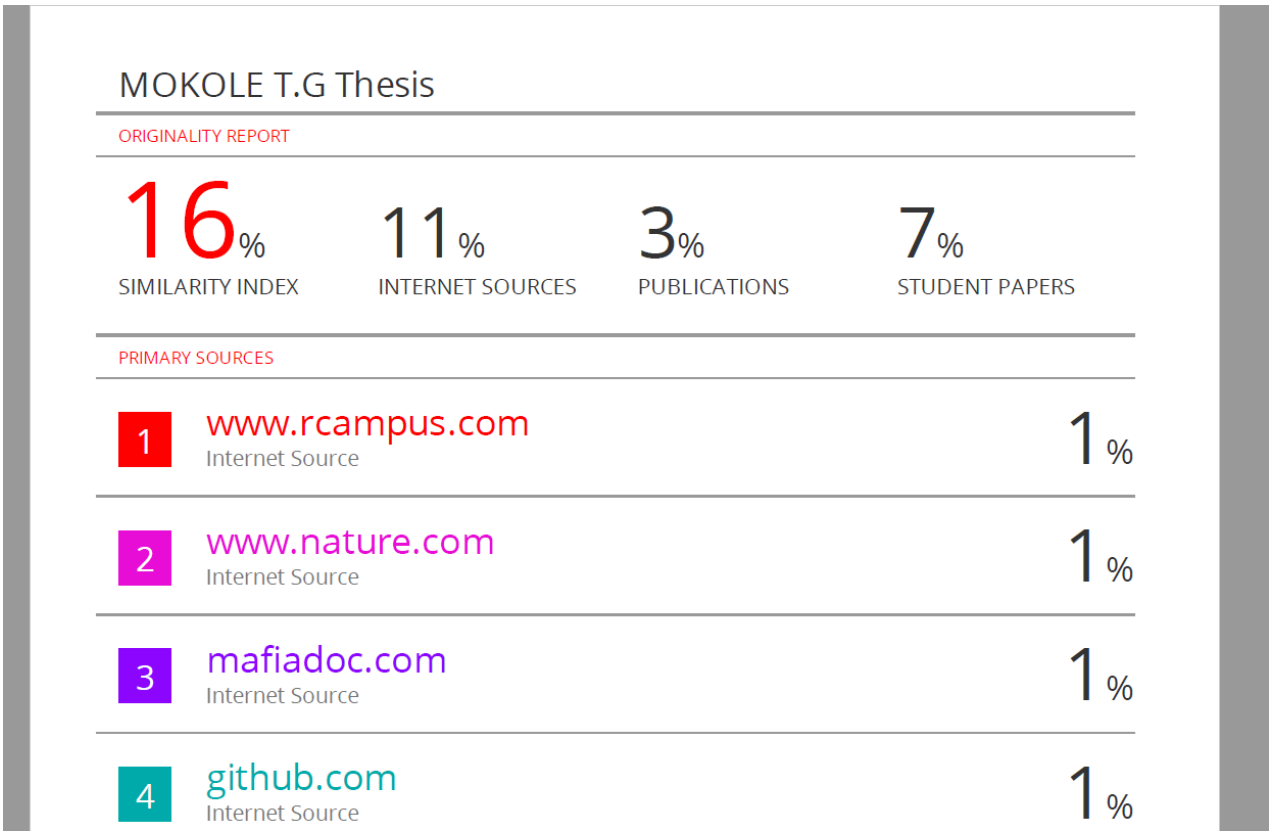
APPENDIX 1: Turnitin Report



MOKOLE T.G Thesis

ORIGINALITY REPORT

16%	11%	3%	7%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.rcampus.com Internet Source	1%
2	www.nature.com Internet Source	1%
3	mafiadoc.com Internet Source	1%
4	github.com Internet Source	1%

Exclude quotes :Off

Exclude bibliography :On

Exclude matches :Off

APPENDIX 2: Ethical Clearance

UNISA university of south africa

UNISA COLLEGE OF SCIENCE, ENGINEERING AND TECHNOLOGY'S (CSET) ETHICS REVIEW COMMITTEE

30 November 2020

ERC Reference #: 2020/CSET/SOC/055
Name: Marcia Mkansi
Staff #: 90215028

Dear Prof. Mkansi

Decision: Ethics Approval from 30 November 2020 to 29 November 2023 (No humans involved)

Researcher: Prof. Marcia Mkansi
Department of Operations Management, Mkansm@unisa.ac.za,
076 833 3274

Working title of research:

Academic Rating Index (ARI)

Qualification: Non-degree

Thank you for the application for research ethics clearance by the Unisa College of Science, Engineering and Technology's (CSET) Ethics Review Committee for the above mentioned research. Ethics approval is granted for 3 years.

*The **negligible risk application** was expedited by the College of Science, Engineering and Technology's (CSET) Ethics Review Committee on 30 November 2020 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment. The decision will be tabled at the next Committee meeting for ratification.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa COVID-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

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3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the College of Science, Engineering and Technology's (CSET) Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
8. No field work activities may continue after the expiry date 29 November 2023. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note

The reference number 2020/CSET/SOC/055 should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.

Yours sincerely,

Dr C Pilkington
Chair of School of Computing Ethics Review Subcommittee
College of Science, Engineering and Technology (CSET)
E-mail: pilkicl@unisa.ac.za
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Prof. B Mamba
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