Professional perceptions of right-first-time and quality management in construction projects through open-ended feedback

Abstract

Purpose – The construction industry has struggled to deliver schemes on time, to budget and right-first-time (RFT). There have been many studies into non-conformance and rework through quantitative research over the years to understand why the industry continues to see similar issues of failure. Some scholars have reported rework figures as high as 12.6% of total contract value, highlighting major concerns of the sustainability of construction projects. Separately however, there have been few studies that explore and detail the views of industry professions who are caught in the middle of quality issues, to understand their perceptions of where the industry is failing. As such, learned this paper interrogates qualitative data (open-ended questions) on the topic of non-conformance and rework in construction to understand what industry professionals believe are the causes and suggested improvement areas.

Design/methodology/approach – A qualitative approach is adopted for this research. An industry survey consisting of seven open-ended questions is presented to two professional working groups within a tier 1 contractor, and outputs are analysed using a statistic software (NVivo 12) to identify prominent themes for discussion. Inductive analysis is undertaken to gain further insight into responses to yield recurrent areas for continuous improvement.

Findings – Qualitative analysis of the survey reveals a persistent prioritisation of cost and programme over quality management in construction project. Furthermore, feedback from construction professionals present a number of improvement areas that must be addressed to improve quality. These include increased training and competency

investment, overhauling quality behaviours, providing greater quality leadership direction, and reshaping the way clients govern schemes.

Originality/value – This paper addresses the highly sensitive area of quality failure outcomes and interrogates them via an industry survey within a major UK contractor for feedback. Unique insights are gained into how industry professionals perceive quality in construction. From previous research, this has been largely missing and offer a valuable addition in understanding the 'quality status quo' from those delivering schemes.

Keywords Construction, open-ended questions, qualitative method, right-first-time delivery, practitioner survey, lessons learned, NVivo 12

Paper type Research paper

1. Introduction

Historically and to date, non-conformance and rework plagues the construction industry as projects struggle to grapple with stringent programme and cost requirements without compromising quality outcomes (e.g. Abdul-Rahman *et al.*, 1996; Battikha, 2008; Ford *et al.*, 2023). Furthermore, the reality that rework in itself leads to further time and cost overruns along with prolonged contract completion dates that could be avoided in many cases is deeply concerning (Love, 2002; Ye *et al.*, 2015). In the last decade alone, researchers have quantified rework costs as high as 16.5% of total project value, urging a need for radical change (Forcada *et al.*, 2014). Furthermore, quantitative methods to unearth rework causes and costs have been positive to inform on how the construction industry is coping (e.g. Love and Edwards, 2005; Forcada *et al.,* 2014; Ford *et al.*, 2023). Moreover, key learning outcomes are being generated to spark continuous improvement initiatives and help drive RFT (Ford *et al.,* 2023). Yet, lessons are not being learned or communicated sufficiently, leading to repeated issues across many construction schemes (Taylor *et al.*, 2012; Love *et al.*, 2022). To understand the magnitude of costs, the UK

construction industry alone is estimated to waste £5.1bn per annum on rework, expressing the importance for change (Get it Right Initiative, 2018). Tackling safety and eliminate harm has been a major initiative for the construction industry, and rightly so. However, other scholars have noted that this has diverted focus from quality within organisations and the contracts they deliver (Love *et al.*, 2019). Love (2020) requests the need for organisations to commit to creating an environment for people to 'get it right-first-time' in projects with authentic leadership, error management, and psychological practices. Furthermore, there has been calling for less of a reactive approach to quality management, and more proactive measures in tackling rework that align to current safety measuring (Love *et al.*, 2023). It is felt that presently, opportunistic, risk taking behaviours to meet programme and schedule are hindering the ability to achieve RFT (Love *et al.*, 2019). This calls for a greater understanding from those delivering projects as to why the construction industry is struggling to address poor quality performance, and what they believe the solutions to be.

As such, this paper aims to (i) Extend non-conformance research outcomes from previous research (Ford *et al.*, 2023) and interrogate seven open-ended questions from an industry survey presented to two professional groups using NVivo 12 to unearth prominent themes, (ii) conduct further inductive analysis of each question to generate collective avenues for improvement from both groups, and (iii) share wider lessons learned within the industry that can positively influence improvement to drive RFT outputs.

2. Literature review and theoretical background

Previous literature, including a recent paper (Ford *et al.*, 2023), have provided knowledge and understanding of prominent rework patterns, unearth cost implications and target avenues for improvement in construction through non-conformance reports (NCRs).

There have however been varying themes on the most prominent and costly causes of NCR as a result of project type and scale. For example, Ford *et al.* (2023) conclude from data supplied by the UK's largest highways project that materials management, workmanship, and supervision were the most prevalent NCR root causes. Their recommendations were for a greater leadership, improved competency assessments, and a need to re-evaluate how projects manage materials through advanced digital capabilities. Forcada *et al.* (2014) on the other hand found that the top causes of rework through non-conformance in highways projects were as a result of scope change, high complexity, poor skill levels, and unexpected ground conditions. They called for greater investment in the preliminary design phase, and enhanced focus on risk management to address rework challenges. Notwithstanding differing outcomes, these types of case studies have provided helpful insight to the pitfalls of construction quality through non-conformance reporting.

Battikha (2008) defines non-conformance as a 'finished state of a project and/or its components deviating from established requirements'. Reports are generated for works that deviate from requirements and are categorised on projects as NCRs. These are raised in the preliminary design and construction phases of projects as an assurance mechanism for the build, and to ensure non-compliant works are corrected prior to client takeover. A by-product of NCRs is the necessity of redoing an activity to meet requirements (i.e. rework). Defined as 'the unnecessary efforts of re-doing a process or activity that was incorrectly implemented at the first time', rework has been noted as prevalent in the construction industry (Love and Edwards, 2004). Unsurprisingly, rework is one of the biggest dilemmas on construction projects. It inevitably leads to cost and time overrun which is usually realised during the handover into operational maintenance process as the

product is vetted heavily prior to taking ownership by the relevant authority (Trach *et al.,* 2021).

Table 1 provides a theoretical framing for this paper with supportive literature on non-conformance and rework to help uncover literature gaps, and generate research questions. Although there are many scholars who have interrogated rework data to understand significant root cause themes (e.g. Abdul-Rahman *et al.*, 1996; Forcada *et al.*, 2014; Oyewobi *et al.*, 2016), some who have derived associated rework costs (e.g. Love and Edwards, 2005; Forcada *et al.*, 2014; Ford *et al.*, 2023), and a selection who have informed learning outcomes (e.g. Taylor *et al.*, 2012; Love *et al.*, 2022), there is very little research on open-ended feedback from industry practitioners on what they perceive to be the cause of poor quality in construction, particularly those who have bolstered their quantitative findings with qualitative feedback to get a full reflection of quality management in construction. For the purpose of this paper, 'professional perceptions' are defined as 'the views and opinions of industry practitioners through their experiences of quality management'. But which professional perceptions are best to understand how projects are performing with regards to 'quality'? Although there are wide range of professional levels and roles in construction projects, many simply don't understand the challenges and pitfalls of quality within their construction projects (e.g. administrators, purchasing departments and human resources). There are however two two distinct professional working groups that can provide a detailed accounts of quality performance in construction projects. The first group is Contract Leaders (CL) who manage projects, and typically have a rounded knowledge of cost, safety, programme and quality performance. The second group is the Quality Community (QC), consisting of a wide range of quality professionals who routinely interact with quality daily, and are closest to construction quality performance. By targeting these two groups, researchers can

understanding whether there is consensus in the ranks of projects, or there is a divide in understanding.

There have been studies that have adopted questionnaire surveys to collect feedback for analysis, but few on the broader topic of quality management through free text responses. For example, Foroutan Mirhosseini *et al.* (2022) focused specifically on factors leading to cost inaccuracy in infrastructure projects, Aibinu and Odeyinka (2006) target the causes of construction delays, and Mahamid (2017) pivots his research around the main rework causes of change orders. Ye *et al.* (2015) on the other hand does consider rework as a whole, but presents questions in a ranking format, removing any opportunity to add qualitative data to examine further. Each study mentioned provides important insight into the causes of rework for their specific topic, but each lacks qualitative insight through free-text feedback using quotations and statements made by industry professionals. To the authors, it is vitally important to contextualise, validate, prioritise and enrich qualitative outcomes, similar to what has been observed in safety (Shepherd *et al.*, 2021). It would appear there are knowledge gaps in what project professionals 'really' think of quality management in construction projects and where improvements can be made to achieve RFT through professional perceptions. As such, our research questions are:

Research question RQ1. What are professional perceptions of the most critical areas for improvement from an industry non-conformance survey in construction projects?

Research question RQ2. How can practitioner feedback help the construction industry improve quality performance and achieve RFT?

3. Research Method and Design

2.1 Context of the study

Our previous quantitative works (Ford *et al.*, 2023) analyse non-conformance data from the A14 Huntingdon Improvement highways scheme (value circa £1.5Bn) to understand common failure themes, poses a series of closed-ended questions to industry professionals within the tier 1 principal contractor via an intricate survey, and generate collective conclusions from the findings.

This paper specifically focuses on the qualitative aspects of the research by delving into the seven open-ended responses to identify whether contract leaders and quality management professionals can provide meaning and solutions to problems in the construction industry.

2.2 Research design path

To gain a full perspective of quality management and help triangulate the findings, supporting quantitative findings with qualitative analysis are advised (Love *et al.,* 2002). Outcomes from both research streams help to generate a holistic view and strengthen the overall findings with a 'real world' perspective (Yin, 2015). As such, a qualitative approach consisting of open-ended survey questions was deemed most suitable (Reja *et al.,* 2003).

To understand how project professionals are reacting to quality management within construction, Figure 1 presents the research design path followed by the researchers. The process begins with obtaining previous findings from a quantitative dataset (Ford *et al.*, 2023), and developing a questionnaire containing seven open-ended response questions to allow the respondent to explain their thoughts of specific quality related areas. One advantage of open-ended questions is the possibility of discovering the responses that individuals give spontaneously, avoiding bias that may result from suggesting responses through closed-ended questions (Reja *et al.,* 2003). Although challenging to analyse, the researchers saw open-ended questions as an opportunity to capture more detailed

perceptions of construction quality from industry professionals, and help strengthen a rounded conclusion to RQ1 through qualitative techniques.

Prior to disseminating the survey, consideration as to the target audience and the most effective way to capture qualitative feedback. Noting the significant advantages of digital surveys (e.g. wider reach of respondents, less paper wastage, increased time efficiencies during data collection etc.), Microsoft forms was selected as an appropriate tool for capturing feedback (Brandenburg and Thielsch, 2009). In addition, to ensure that the questionnaire was relatable to those managing quality on schemes, a pilot trial was conducted with five engineering experts with a minimum experience of 10 years in the fields of project and quality management. Once feedback had been received and changes implemented, the survey was rolled out to 162 individuals within two professional working groups of a tier 1 contractor. Both groups were given one month to respond to the survey before the portal closed. In total, there were 21 contract leaders (CL) and 38 quality community (QC) professionals who took part in the survey, yielding response rates of 31.3% and 40% respectively. These groups were targeted for their influence and understanding of quality management on construction schemes, one from a high level, strategic perspective, and the other from a detailed, 'hands on' perspective.

Once feedback was received, the data was exported into an Excel document, checked for grammatical errors and categorised into a compliant format ready for qualitative analysis.

2.3 Qualitative analysis process

This study opts to undertake statistical analysis using NVivo 12, coupled with inductive analysis to ascertain meaning from a series of responses to each question.

Developed by QSR international in 1997, NVivo is a prominent software application that has proved effective in helping researchers to understand more complicated qualitative

datasets. Furthermore, there are researcher who claim that software applications such as NVivo can improve the quality of analysis over more traditional, manual techniques (Dhakal, 2022). However, the software does not discount the need of a human researcher, but instead assists them in organising and structuring their data. One advantage of using NVivo 12 specifically is the ability to collect, organise, interrogate, analyze, visualize and report data with files that are stored either internally or externally to a project database (Franzosi *et al.,* 2013). A further advantage is the ability to quickly analyse large free text datasets, and reduces the laborious task of sifting through data manually. This affords researchers more time to recognise themes, discover tendencies and derive conclusions (Hilal and Alabri, 2013). As such, NVivo 12 was considered an optimal software to analyse qualitative outputs, and selected for this research.

Prior to using NVivo 12, greater knowledge and understanding of how the statistical software works was required. Figure 2 presents a process map that was adapted from Hilal and Alabri (2013) to provide logical steps of how to capture and analyse qualitative survey data.

Once training had been completed (*step 1*), a new project template was created within NVivo to capture imported documents (*step 2*). Following this, an excel export of the survey was taken from Microsoft Forms at which point the data was cleansed of grammatical errors, removed of closed-ended questions and any sensitive information (i.e. names), columns and rows were reorganised into a logical format and the files were import into NVivo 12 (*step 3*).

NVivo 12 provides a fast and efficient way of coding data through its auto-coding function (Hoover and Koerber, 2009). This method automates the routine and mechanical aspects of qualitative research, allowing the researcher to spend more time on the interpreting and creating new insights from the data. Codes are automatically created for

words that have been used frequently within qualitative data which emphasise the most commonly discussed topics requiring further review. In the case of this paper, auto-coding was performed to provide consolidate coding and analysis down to a few minutes rather than days manually (*step 4*). Once each data entry had been coded, the following exercises were performed (*step 5*):

(1) Run a word frequency query for each question within each group of data to provide a high level understanding of the most used words via a word frequency table summary and word cloud.

(2) Run a specific text search query on the five most frequently used words found within each question with criteria of 100 most frequent display word selected, a minimum letter length of 4, and with stemmed words applied.

(3) Conduct further inductive, thematic analysis of the five most discussed words for each question to yield collective outcomes worthy of discussion and reflection.

On completion of step 5, results of each question were deduced by filtering the original Excel spreadsheet for the five most frequently occurring words and thematically interrogating the transcripts. This method allowed the research team to focus efforts to collective points of discussion, provide greater context to the word frequency, and help understand whether the response was in a positive or negative capacity. Findings were collated and presented as a series of tables and figures for further discussion and conclusion.

4. Findings

Table 2 presents the referencing structure used to identify respondent feedback and quotations within this paper, including gender and job role within their organisation.

The forthcoming section is split into the relevant open-ended questions in order as they appear within the survey. All of the open-ended questions are preceded by close-ended

questions that question whether there is a problem (Appendix I). Each open-ended question undergoes the same interrogation process aforementioned within Figure 2 to present findings in the form of a word frequency summary that shows the total word count and weighted percentages along with word cloud visuals of the 5 most frequently discussed words uncovered by NVivo 12. Although NVivo is a powerful tool for rapidly organising data to focus on trends, outcomes must still be interpreted to contextualise against each question posed. As such, manual interrogation of the data was performed on the five most frequent words with NVivo's text search function.

Appendix II presents statistical outputs for each question which are further analysed and discussed below.

Question 10 - What do you believe is the potential consequences for proceeding at risk without approved designs (Both positive and negative)?

Previous quantitative findings suggest that projects are proceeding at risk without designs many times throughout a project lifecycle (Appendix II, Q9). An overwhelming agreement from industry professionals that meeting programme and taking risks is happening more often than not. Therefore, we asked contract leaders and quality professionals of their views on proceeding at risk without design approvals.

Of the collective responses, Table 3 presents the positive and negative outcomes that projects professionals felt were valid for proceeds at risk with trailing design approvals. Both groups validate concerns that the negatives significantly outweigh the positives when proceeding at risk without approved design details. Contract leaders presented 5 positive and 10 negative outcomes. Some of the negative outcomes include higher risks of rework, scope uncertainty, greater quality and safety issues, cost and time escalations, behaviour issues, reputational damage and relationship breakdowns being many of the

significant implications of proceeding at risk. Of the positive responses, the need to meet critical programme deadline dates and alleviate project overheads onto the next scheme appear the most influential drivers for contract leaders. There are some who feel that delay damages from not meeting key project milestones are far more significant than rectifying defective works which likely influences the behaviour (CL03). Quality professionals on the other hand gave 4 positive and 13 negative views with similar feedback. However, there was far more negativity for making decisions to proceed at risk.

In fact, a few individuals from the quality community were strongly of the opinion that there are no positives to proceeding at risk (e.g. QC15). Much like safety, they felt that one incident is more than enough and deemed unacceptable. Accurate designs and early design freezes have been considered a critical success factor to project deliver that must not be overlooked (Wuni and Shen, 2020).

One benefit stated by a number of contract leader is that proceeding at risk to meet programmes will reduce overhead costs. This can only be true if their assumptions are correct about the design and no further changes occur. From the researchers' experience, handover operations, whereby projects resolve defects, respond to queries, consolidate late quality assurance deliverable and other missed tasks have a far greater effect on resources. In fact, some schemes (e.g. Crossrail) have succumb to years of testing, commissioning and handover pain to satisfy completion, some of which may be down to late design change and proceeding at risk (Landis, 2022). In addition, design changes have been considered important causing factors of project delays and cost overruns that burden project handover (Abdul-Rahman *et al.*, 2015).

Question 13 – Do you think that cost and programme are more important than quality delivery? Please explain.

Noting that 100% of both groups felt that cost and programme are treated as higher priority that quality delivery (Appendix II, Q12), we asked whether they felt cost and programme are more important than quality and to explain why.

Results indicate that there were 14 contract leaders who stated directly that they did not believe cost and programme are of greater importance than quality, accounting for 66.67% of the group. There were a further 6 responses (28.57%) that skirted around a direct response and commented purely on the reason why this phenomenon occurs, and 1 respondent who felt that cost and programme are of greater importance (4.76%). Similar with the quality community, there were 23 professionals (60.53%) who were strongly of the opinion that quality is equally important as cost and programme, and 15 respondents (39.47%) who did not provide a direct response, instead focusing on justifying why cost and programme take precedence. Both groups identify the intertwined nature of cost, time and quality within the iron triangle having direct consequence on one another as other researchers have alluded to previous (Pollack et el., 2018). Furthermore, they acknowledge and appreciated the knock-on effects cost or programme have on quality. Moreover, both parties expand on their concerns that failing to deliver quality leads to unplanning and un-forecasted cost and time event which are more damaging as they will take longer to resolve. Focusing on 'why' decision making is geared toward prioritising cost and programme, findings from the responses are summarised below.

Of the contract leader responses, the following themes encountered:

[1] ***Client and stakeholder requirement*** – The majority of comments made to cost, time and programme were geared toward clients requirements. There were many concerns that fundamentally it is clients who set unrealistic cost and programme expectations that have been driven through political pressures to mitigate taxpayer spend and limit disruption.

As such, the influence of prioritising cost and programme over quality is heavy influenced from above which drives greater focus on these by clients down through to project teams. In addition, clients organisations have been perceived to focus on cost and programme with the expectations that quality will "just happen" (CL10). Furthermore, contract leaders feel that their clients drive behaviours to complete works and deal with defects outside of key funding milestones. It would appear that if clients significantly influence decision making to prioritise cost and programme, re-education of the impact these variables has on quality is needed at a senior leadership level.

[2] ***Culture and behaviours*** – There were multiple comments of the project delivery mindset to narrow focus on cost and time as these are tangible, measurable lagging indicators used to monitor performance, whereas quality performance measures were noted to be less accurate and more challenging to report (CL07). As such, projects typically take a short term lookahead (e.g. twelve weeks) instead of recognising long term consequences of contract completion (CL04, CL07 & CL11).

From the 21 responses, only one individual (CL03) gave interesting insight as to why cost and programme are more important in their view. They comment, "*Because they are. There is no point creating a perfect quality scheme that is late and over budget. Sometimes we have to accept that we will do an imperfect job on certain activities in order to achieve the overall aim of the scheme."*

Project teams, clients and stakeholders must strike a balance that meets the expectations of all parties including clearly defined requirements for a quality end product that meets cost and time assumptions, i.e. the iron triangle (Caccamese and Bragantini, 2012).

Reflecting on the quality community responses, similar patterns are shared with contract leaders. Firstly, quality professionals concur there is a lack of maturity from clients who

do not appreciate the benefits of achieving RFT over hastily delivered projects. More concerning, they believe this behaviour is unlikely to change anytime soon with ever tightening budgets, greater public awareness and heightened political pressures to deliver. Secondly, there are concerns that a lack of quality investment is making it more challenging to measure quality metrics that should be measured, i.e. supply chain performance, RFT execution, quality behaviours and quality risks (QC24). One quality professional quoted, *"Cost and programme first is a false economy with incorrect perceptions that projects will find time at the end of programmes to rectify issues."*

In essence, without clearly defined quality metrics, there are concerns that the construction industry is unlikely to improve and will continue to "*lag behind more mature sectors, most of which have realised the importance of quality by adjusting their way of thinking*" (QC17). Ensuring quality and safety performance demonstrate RFT delivery was concluded as a number one priority without exception. By embedding this cultural approach into project thinking, quality professions feel it will help correctly drive programme along with providing adequate time and resource to plan the work, whilst maintaining cost performance projections (QC34).

In addition to areas discussed, quality professionals had further concerns around leadership that was not identified by contract leaders.

[3] ***Leadership*** – There were numerous concerning statements over minimal direction and vision that leaders instil on their projects to provide clear quality objectives, continual advocate and promote quality performance, and assign accountability, consequence and reward for quality outcomes. For example, there were two quality practitioners (QC34 & QC38) who noted the lack of quality strategy and plan to provide a clear vision of quality on equal terms to safety, cost and programme objectives that would develop an RFT

culture, and a "*stop if not right*" culture if poor quality performance ensues. Contract leaders and quality professionals are in agreement that projects do not see the same willingness from front line workforces to stop works on the grounds of failing quality as would be seen from breaching safety standards. In safety, there is no hesitation to interject, whereas in quality, individuals carefully consider their decisions as not to compromise programme led by pressures from above to meet key delivery dates. In certain cases, teams may progress knowing the works are defective to not compromise critical path milestones hoping they will find enough time at the end to rectify.

The second generalised comment made by the quality team that was not considered by contract leaders what the role and perception of a quality team which is discussed further below:

[4] ***A quality teams' image*** – More than 50% of the responses made comments about how quality personnel are perceived on projects, being seen as "*quality police or pedantic / fussy*" rather than embedded members who are committed to helping drive project success (QC08). This reinforces concerns of site behaviours who notedly are under tremendous pressure to deliver schemes as quickly and cheaply as possible, driven by cost and programme from leadership. These behaviours have manifested all the way up to leadership where claims have been made that quality professionals do not feel their voices are heard or valued when faced with quality issues. One individual specifically commented "*who cares what quality professionals think*" (QC03), bringing into question the collaborative inclusion of quality personnel along with authority to make impactful decisions for the betterment of projects.

Question 16 – Do all parties on our project fully appreciate and understanding the level of quality to be achieved? If 'No', why do you believe this is the case?

Previous findings indicate that 13 of 21 (61.9%) contract leaders and 24 of 38 (63.2%) quality professionals felt that quality standards were not fully understood by all parties. We therefore asked why they believe this to be the case (Appendix II, Q15).

A deep dive into the five most frequently discussed words indicates an overwhelming agreement that project stakeholders and the teams managing them have varying expectations of quality standards including what is deemed acceptable (i.e. fit for purpose). The subjective nature of what is deemed acceptable has proven challenging to date. Both groups acknowledge that the likely cause of this is lack of early engagement, communication of proposed requirements and agreement at the beginning of projects. Instead, a siloed atmosphere ensues, presenting further challenges with a mixed understanding of what is to be delivered. For example, one contract leader explained that they have experienced client business silos with different and competing objectives/drivers. Architects may require a fine finish, operations will insist on a minimal maintenance solution, the technical approval department will expect recognised engineering standard outputs, commercial management want the cheapest solution and project sponsors want a minimal impact solution that does not disrupt the public.

Agreeing quality requirements between clients, principal contractors and stakeholders is one thing, however there were comments from contract leaders that such discussions are not exacted onto supply chain, nor have they been invited to contribute to quality output discussions as the works specialist. As a result, if and when communications are disseminated down to supply chain, it's too late.

Lastly, there were comments that a lack of training and education of quality requirements is clouding the issue of what is deemed acceptable. Instead, individuals or groups revert to previous project experiences. One contract leader (CL16) stated, "*People remember*

the quality requirements of the previous longest serving project they had been involved in and therefore breaking habits are often difficult".

On review of the quality community responses, they perceive quality standards as somewhat tactical to benefit each parties interests. Unfortunately, in many cases, interests are not aligned so a balance must be struck. For example, one quality professional (QC01) presented an example using quality of cars with the quote: "*Clients want a Rolls Royce finish, specifications and requirements accept a Ford, and project managers want to deliver the most basic car possible*". Most own a car and understand the nuances between low, medium and high quality outputs (e.g. between a luxurious Rolls Royce and a mid-range Ford).

If the sponsor has not budgeted for a superior product (i.e. a Rolls Royce), it would therefore seem unfeasible to expect more than what has been priced (i.e. a Ford). Unfortunately, quality professionals have growing concerns that clients do try and get as high quality finish as possible and expect more than what they are prepared for. Therefore, expectations must be managed. Collectively, this specific example of Rolls Royce was commented on by two contract leaders (CL02 & CL05) and three quality professionals (QC01, QC20 & QC38) as a way of expressing the sliding scale of quality expectations.

Another similar claim made by the quality community was the poor communication of agreed requirements down through to supply chain who sometimes have different outlooks on quality requirements. With projects often starting abruptly, quality expectations are not defined, agreed and communicated effectively through kick off meetings that involve the client, designer and supply chain (QC02). Instead, projects are proceeding with the mentality "*that is the way it's always been done*" (QC26). Furthermore, quality professionals are concerned that clients and designers do not

willingly contribute to discussions on quality requirements, and instead just leave it for the project team to interpret. This reinforces a message for clients and designers to take time to reflect on quality expectations and requirements that are within the schemes budget (Kaur *et al.* 2019).

Question 19 – Analysis of 1260 nonconformances indicates rework costs of 0.5% of the total project value (£7,739,850). Is this figure of concern? Please explain your answer.

From the quantitative results, a major highways scheme experienced a 17% profit loss figure to rework (Appendix II, Q18). 20 contract leaders (95.2%) and 37 quality professionals (97.4%) were seriously perturbed with the 17% profit loss, but why? Question 19 provided the respondents opportunity to share their reasoning via a free text response.

On closer review of responses that raised concern for the findings presented within the survey, there were seven contract leaders who feared that a figure of 17% is likely to be conservative as costs are not accurately or correctly recorded. In reality, they believe they believe this figure is significantly higher and poses even greater risk to company profits. Furthermore, when factoring in direct and indirect costs, there are likely to be hidden costs unaccounted for such as design change, process overhaul, investigative time etc.

Another concern made by contract leaders is the impact that such rework costs have on projects and their parent organisations. Specifically, not only did they mention the obvious fact that such outcomes will affect profitability but the logistics of rectifying rework (i.e. rectifying non-conformance requires additional time and effort to resolve, and takes resources away from closing out remaining works within contract scope).

Any impact on profit margin has been commented as concerning as this is how business prove viability to its stakeholders. One contract leader stated, "*17% margin erosion is*

massive" (CL12). Another stated, "*effectively this is profit going needlessly out the door, and to recoup this profit loss would take a significant amount of future turnover*" (CL04). The dataset is based on the largest construction company in the UK. Not all schemes are of this magnitude so will take longer to recover, however this is conditional that no rework will occur which is seemingly unlikely.

Of the quality community responses, they too agree with contract leaders that the figure is low and believed this cost only scratch the surface. For example, respondent QC15 commented "*The figure could be significantly higher - refer to Get It Right Initiative (GIRI) data - up to 25% of project costs, therefore the problem or opportunity is also larger*". Latent defects and other late changes are rarely incorporated within non-conformance and rework figures as teams and their processes have disbanded. Quality professionals also identify the issues with the accuracy of indirect costs from supply chain, designers and clients. Furthermore, the direct costs that principal contracts incur such as management, administrative time, traffic management, further inspections, evidence reviews, field supervision, additional safety implementation and programme impacts have been commented on as some of the missing costs of non-conformance and rework (QC13 and QC38). Eight quality community respondents conclude that in reality, without question, non-conformance costs are undervalued and exponentially higher than reports, both directly and indirectly (QC04, QC13, QC15, QC17, QC21, QC23, QC24 & QC26). More significant cost outcomes will have a more significant impact on profit loss, reputation and growth within the construction sector.

Other concerning factors made by the quality community referred to behaviours, training and competence that has great impact on profits. Five respondents elaborate that the culture of quality at present does not appear to have progressed towards 'right-first-time' delivery and is still geared towards cost and programme outputs. Unless this changes,

similar outcomes will continue to occur as works are rushed, corners are cut and mistakes are made. Quality professionals have called for leaders to invest more heavily in people, process, systems and technology to help adapt the culture of quality in construction, with greater emphasis on leadership direction of which is severely lacking in the many sectors not just highways (QC02 & QC04).

A separate apprehension made only by the quality community was the reputational damage such quality outputs and profit loses have with clients and shareholders (QC10, QC12, QC13 & QC21). Clients will lose confidence and are less likely to award future work to contractors who continue to demonstrate poor quality management. Likewise, shareholders will be unwilling to invest in failing, high risk portfolios and look elsewhere. Continuing high rework costs on current highways schemes indicate that the company is still not learning lessons from non-conformance and continuing to make unnecessary mistakes (QC06 & QC16). Furthermore, high costs reflect that the prime causes of rework are not being addressed and can continue to manifest elsewhere. The group responses reiterate that quality awareness and changes of behaviours need to be led by leadership as a fundamental step change, inflicting consequence and reward for quality outcomes.

In conjunction with leadership is how the organisation budgets schemes to de-risk and protect profit margins (i.e. at tender phase). Quality professionals acknowledge that human error will happen and delivering projects with zero rework cost is extremely unlikely. However, during tender and budget agreements, no rework cost is account for and will immediately erode profit margin (QC27). It is even more important with this knowledge that leaders re-evaluate their initiatives to reduce error and protect profits by not chasing programme and cheapest options. A proportional cost of error assumption should be built into projects to transfer a portion of risk onto clients, where they pressure contractors to focus on key milestones instead of delivering a quality product. One quality

professional (QC35) likened it to "*supermarkets budgeting for shoplifting*". It's about having a fair understanding of risk and apportioning between engaged stakeholders.

Question 20 – The most frequent NCR root causes were found to be materials management, poor workmanship and supervision. What do you believe we should focus on to prevent repetition of future schemes? Please list.

Question 20 presented the three most frequent non-conformance root causes from the quantitative data analysis as materials management, poor workmanship and supervision (Ford *et al.*, 2023). From this, both groups were asked where they would focus efforts to prevent repetition on future schemes.

Although the word frequency findings broadly identified areas for improvement (Appendix III), a lack of specific detail of 'what' and 'why' called for further interrogation. Therefore, an intrusive review of each response was performed and summarised in Table 4. The table presents figures on consolidated themes where each party felt improvements were vital for future scheme success.

On review of Table 4, there are interesting collective themes worth of discussion. Firstly, both groups confirm the same five most fundamental areas requiring improvement both at a project level and company level. These are [1] workforce competence, commonly referred to as suitably qualified and experienced person (SQEP) with 28 collective counts, [2] quality culture with 18 counts, [3] materials management with 15 counts, [4] supervision with 14 counts and [5] leadership with 13 counts. Of these areas for improvement, workforce competence was by far the most discussed topic with many referencing their concerns that within engineering as a whole, workforces are not adequately trained, educated and coached sufficiently through their professional development journey to build greater levels of expertise and knowledge in key delivery

roles (i.e. engineers, supervisors, managers, surveyors etc.). With regards to training and education, both groups felt strongly that engineers and supervisors in particular would highly benefit from mandatory institutionalised training from a certified organisation (CL21 & QC17). In conjunction, onsite grass roots training to put methods into practice with support from more experienced, knowledgeable members to show how works are to be done correctly, whilst understanding the do's and don'ts as a form wisdom sharing would prove invaluable.

In connection with workforce competence, both groups confirm the current struggle of securing and retaining experienced, knowledgeable engineering professionals who see quality as a key delivery requirement (QC14). Instead, once maturity level has been reached, competent personnel often opt for a more substantial, challenging role. Lack of appreciation, role progression and incentivisation have been listed as attributing factors (CL08 & CL12). This topic transitions across to the quality culture of projects and companies where there were 18 comments made on the grounds of poor or lack of culture within quality. Each party validates that quality culture has not progressed to date as has been seen with safety which has been on the forefront of leadership agendas (CL04, CL05, QC06 & QC21). It would appear workforces continue to lack accountability, consequence and incentivisation for quality outcomes (CL12 & QC13). Furthermore, project professionals acknowledge that leadership continues to lack vision, investment and priority of quality requirements. Without this, projects will lack direction and continue to chase programmes. There have been collective suggestions from the responses of both groups to re-assess project engineering, supervision and quality resources to ensure schemes are properly managed rather than overworked. In addition, they feel that better systems setup (i.e. in advance of construction) and processes for managing quality along with more applicable, performance related quality key

performance indicators (KPI's) will help address leadership, culture and SQEP resource challenges (i.e. quality culture and leadership improvement through business initiatives focusing on poor performing areas).

Regarding the category materials management, there were suggestions that better technologies, systems and processes along with enhanced planning may overcome challenges of material non-conformance, help alleviate miss-communication, and identify potential issues before they are delivered to site. Greater calling for digitalisation to play a part in helping to track weather events, live traffic conditions and other uncertain variables could be a viable solution but will require buy in from suppliers.

Question 22 – You've selected 'Yes' to the previous question. There were 137 cases of poor/lack of supervision and a further 26 cases of competency/training issues notified via non-conformance reports. What do you believe the solution to be?

The prior question (Appendix II, Q21) suggested that 90.5% of contract leaders and 94.7% of the quality community agreed that the industry is struggling with SQEP resources. Supervision in particular yielded 137 root cause cases along with a further 26 specific cases of competence/training issues from a highways megaproject. Question 22 was created to ask professionals where improvements could be made.

Each response was carefully reviewed and collective themes were identified for both groups. Figure 3 presents the most frequently discussed topics for improvement by contract leaders. Of the suggest topics, the three most discussed themes were [1] the need for investment and roll out of applicable, mandatory training for specific key project roles (7 counts), [2] further quality awareness and behavioural management sessions internally and with supply chain (6 counts), and [3] the need to re-evaluate tender resources and

time allocations to provide adequate provisions to complete works in accordance with quality requirements (5 counts).

Beginning with the need for further investment and clarity of training requirements, contract leaders felt that engineering and supervisory resources are becoming less specialist and more generalised in their knowledge and capabilities (CL01, CL02, CL09, CL10, CL17, CL20 & CL21). Furthermore, there were comments that historically, engineering training and site experience such as setting out tasks have proved invaluable in the engineers knowledge skillset, reiterating the need for greater site experience via coaching, more relevant training material that educates and shares best practice techniques in a trade specific format that shares the do's, don'ts and innovate ways to breed RFT outcomes. One contract leader commented that "*The element of 'bringing people on' has disappeared and engineers just want to be Project Managers straight away. Working with the gangs is an invaluable experience*" (CL01). Another called for "*reinstating back to basics site training*" (CL21), reinforcing the need for trade specific training with site experience.

The second suggested topic for improvement calls for greater quality awareness training and behavioural management practices to change the way of thinking for project delivery (CL01, CL02, CL04, CL09, CL10, CL15 & CL17). Concerns were made that training and behavioural management sessions relating to safety are deployed regularly on projects to ensure works are done safely but for engineering and quality in construction there is a missing link, particularly for quality courses that "*give insight into the rights, the wrongs, and the common shortcuts*" (CL02). Suggestion to "*raise the profile*" and awareness of quality by providing education on the impacts, risks and opportunities for quality management (CL10). Many simply don't know or appreciate how important quality practices are until it happens to them in an accountable position. However,

contract leaders do appreciate that training is one thing, but this must be driven by top management to embed accountability, consequence and reward for all (CL18).

The third suggested improvement area was resource and time allocations on projects (CL02, CL03, CL06, CL10 & CL13). Concerns that many schemes are under resourced, causing workloads to pile up on the staff they have. More paperwork, increased responsibilities and less site presence have become attributing factors in not providing due diligent engineering support to front line workers that has led to quality issues. For example, one respondent (CL02) commented "*Our foremen used to have time to educate engineers and they in turn could coach and guide new foremen and engineers. Reporting, paperwork and permits have taken that time away*". Contract leaders have suggested the need for the company to re-consider how much resource and time is required to deliver schemes. SQEP engineers, supervisors and quality resources to deliver schemes successfully must been priced for within budget and tendering assumptions rather than allowing project teams to struggle. In the end, one task will get compromised over another, and it will likely be quality deliverables. Specifically for quality resources, the need to employ more quality roles that give time to focus on quality leadership, management and control that helps to support the project team and offer early insight through quality risk management techniques.

A similar exercise was conducted by the quality community group responses (Figure 4). Of the findings, the same three improvement areas were suggested by the quality community but in different order. These were, [1] the need for greater investment and deployment of specific mandatory training (11 counts), [2] greater provisions of engineering and quality resources with sufficient time allocated to complete the works against quality requirements (10 counts), and [3] more quality specific training,

awareness and behavioural management practices to shape quality culture on projects (8 counts).

Firstly, quality professionals felt that the company needs to provide a more robust syllabus of training for specific roles with supporting training gaps analysis to help develop engineers, supervisors and quality inspectors into highly knowledgeable, experienced resources that treat quality delivery as priority (QC03, QC04, QC12, QC16, QC29, QC30, QC31, QC33, QC34, QC36 & QC38). This needs to be carried out simultaneously with onsite training with more experienced personnel in a coaching capacity to ensure supervision have a nurturing environment to learn before being deployed, rather than being "*thrown into the deep end*" as commented by one quality respondent (QC22).

The second improvement similarly called for by contract leaders is more front line engineering supervision, supervisors, inspectors and quality assurance personnel on projects (QC01, QC06, QC12, QC13, QC15, QC26, QC27, QC30, QC35 & QC36). Better tender assumptions of resources is required to ensure the project can perform adequately is a starting point, with better planning of process implementation to ensure quality assurance hold points are not missed (i.e. inspections and paperwork deliverables that must be satisfied in order to assure schemes). Furthermore, with limited resources were concerns that time spent managing additional responsibilities reduces site presence. One quality professional (QC05) quoted, "*we need to let them do some engineering instead of endless paperwork and supervision of sub-contractors*, insinuating that engineers are being given ever widening project responsibilities rather than focus on engineering delivery. For example, managing a large tier 2 supply chain package in itself is a full time role that often gets bolted onto an engineer's responsibilities.

Third, the quality community share similar suggestions to introduce quality awareness training and behavioural management sessions routinely to adjust industry culture and ethos of quality, with the inclusion of supply chain, designers and clients to ensure all involved in project delivery appreciate the impact and implications of not adhering to processes (QC02, QC07, QC08, QC17, QC23, QC31, QC36, & QC38). One quality professional commented on the need to undertake "*mandated quality awareness sessions looking at the requirements and expectations from the client*" to re-invigorate the importance of quality delivery and understand what clients expect. Sadly, there were claims from quality practitioners that "*a lack of commitment and interest from project management teams to either allow a quality section in the main project inductions or a separate quality induction*" is hindering a clear quality message (QC38).

Question 23 – You've selected 'No' to the previous question. Of the data, there were 137 cases of poor/lack of supervision and a further 26 cases of competency/training issues notified. Why do you think such large figures are occurring?

From the survey, there were only two contract leaders (CL07, CL12) and two quality professionals (QC09, QC18) who answered 'No' to concerns that the industry is struggling with SQEP engineering and supervisor resources (Appendix II, Q21). A follow on free text response question was created to provide feedback on why such high supervision and competence cases are being encountered.

Both contract leaders were of the belief that the industry has more than capable engineers to deliver works, however, wrong behaviours are being driven through lack of leadership and accountability. CL12 stated that projects "*do not create the right environment for accountability*" and "*we are supply chain driven and I believe we take too much of a*

hands off approach". A lack of leadership presence to correctly apportion accountability and consequence is driving the wrong behaviours when managing supply chain. CL07 requests to "*bring quality in house and all own it!*" echoes the need to get more hands on with managing quality and take control.

The two quality professionals on the other hand commented that the fundamental reason for branding personnel as a SQEP issue is the lack of regular training updates, appropriate coaching and clear definition of work responsibilities, particularly when roles change. Respondent QC18 raised concerns that inappropriate role allocation and insufficient coaching means that "*managers set them up to fail*".

5. Discussion, impact and implications

On reflection of the iron triangle debate (Q10), it is apparent that contract leaders see a greater benefit of proceeding at risk to maintain critical path delivery milestones, whereas quality professionals are far more risk adverse. For quality professions, late design changes, non-conformance and rework outcomes all play a major part in their project roles. By adoption a risk-averse point of view, opportunities will be evaluated cautiously (Cretu *et al.*, 2011). Furthermore, limiting risk and change in the design phase, it helps deliver stronger quality management for schemes rather than fixating on resolving issues brought about by late design changes (Wuni and Shen, 2020). Both parties discuss risk management extensively in their responses with relation to the benefits of doing something against the long term impacts (e.g. cost and time overruns). Unfortunately, the industry still does not appear to be in a position whereby there is sufficient evidence to substantiate that long term costs of rework most certainly outweigh the costs of delay damages from critical path programme milestones. As such, there are statements from both groups speculating that remaining on programme and corrective defective works as

they manifest is more financially beneficial than waiting for designs to be approved. In short, if projects are still going to proceed at risk, they need all the facts to ensure they substantiate their decision via a robust risk assessment that yields a low to nil result.

Regarding design change, there is a calling for a re-evaluation of how contracts are set up and administered to apportion risk and consequence fairly. For example, it may be prudent for clients to employ designers to complete the detailed design in full prior to awarding a contractor to undertake the works. This can help negate design change and prevent tensions build up with clients. If design change is a client risk, there may be greater reluctance to change detail requested by various stakeholders. Jackson (2002) called for clients to take greater accountability for design change as a primary risk to project delays. In the last two decades, this still appears a challenge.

Fixating on cost and programme has been a recurring theme throughout this paper. Most professionals do not believe they are more important than quality, however, delivery teams feel their hands are in many ways tied with political pressures from clients, a lack of effective leadership and cultural maturity (Q13).

Regarding quality outputs, it is apparent that there is still confusion of what good looks like (Q16). Striking a balance has proven no easy feat as not all parties will be fully satisfied. Better early engagement with enhanced collaboration, and improved interaction with supply chain is fundamental to present a clear project understanding (Kaur *et al.*, 2019).

For Q19, it is understood that, in reality, costs are far more significant as they are still incorrectly calculated. along with the financial and reputational damages being more severe than perceived. In addition, continuing to yield high non-conformance and rework numbers informed both groups that the industry is not learning from mistakes and that quality culture is stagnated. Behavioural issues, lack of training and competence have

been noted as factors to project quality failures then need addressing immediately, which has also been noted by Love *et al.* (2022).

To enhance materials management, poor workmanship and supervision issues identified through quantitative NCR analysis, project professionals suggest that the company and wider sector should address workforce competence, align quality culture to a similar standing of safety, and re-evaluate how materials are being managed by embedding digital capabilities to better plan, manage and track materials from manufacture through to installation(Q20).

A distressing statistic that the industry is desperately struggling with SQEP resource, the industry must invest more heavily in training and undertake gap analysis to enhance professional development, not simply acknowledge that they don't have the right person for a specific role. In addition, specific quality awareness and behavioural management sessions must be rolled out at regular intervals to increase the dynamic of quality, raise the profile and preach the impacts of poor performance beyond cost and time (Q22). Lastly, with training and a change of behaviours is the need for appropriate resource and time provisions to complete projects in accordance with quality standards. Better tender assumptions and improved planning phases should help to identify clear responsibilities and factor deliverables into contract programmes. With the above calls for greater leadership to embed responsibility, accountability, consequence within internal teams and external supply chain (Q23).

6. Conclusion

This study offers a unique insight into the pitfalls of quality through the lens of construction industry professional. Through a series of open-ended questions tailored by quantitative outcomes from a highways megaproject case study, the researchers were able to identify collective avenues for improvement within the construction industry.

According to project professionals, the paper reveals that the industry should focus efforts in addressing project risk taking behaviours (including clients), enhance the knowledge and experience within the field to provide sound engineering judgement (i.e. SQEP), and improve quality leadership on similar ground to safety. In addition, this paper further notes that clients and contractors must work together to agree quality standards (i.e. Rolls Royce vs Ford), ensure designs are finalised and accurate before works begin, and break the continuing cycle of chasing programme and cost (RQ1). Without clear leadership, investment in quality management systems, processes and personnel, along with defined responsibility and accountability, errors will continue to manifest, and risks will be taken. This paper reveals the importance of professional feedback. It demonstrates that industry feedback from those delivering schemes can significantly help to pinpoint where quality challenged are in construction projects, assess the most critical areas for improvement, and provide solutions to address. The findings also indicate that RFT is only possible with major structural reform, and a change to the culture of quality as has been seen with safety (RQ2). From this research, it is apparent that the construction industry is no closer to achieving right-first-time delivery. Leaders must take note and take action to address the messages from within qualitative feedback and do more regular engagement to understand how the industry is performing.

The contributions of this research paper are threefold. First, by undertaking qualitative research within two professional working groups of a tier 1 contractor, the researcher have uncovered current perspective of quality management within construction that require addressing. Second, the feedback has been collated and synthesised to provide practitioners with key avenues for improvement. Third, as there has been a shortage of literature specifically targeting the opinions of project professionals on their view of quality management within construction projects, this paper contributes to the general

body of knowledge through qualitative outcomes. Collectively, the findings from this research provide an essential understanding of the current landscape for risk and quality delivery in construction projects, and help organisations to re-strategize their continuous improvement initiatives.

The implications of this study call for quality to be re-evaluated at project, company, sector and government levels to overhaul how quality is delivered. Furthermore, the paper identifies critical learning outcomes for the construction sector to take forward, including the need to re-assess projects to ensure they are appropriately equip with competent personnel under a vetted, progressive training programme, share collaborative behaviours that value quality delivery on an equal standing to safety, programme and cost, and tackle the inappropriate resource dilemmas projects finding themselves in through clear tendering and accurate planning. In addition, before making erratic decisions, projects must assess the risk profiling of proceed without approved design details, and include the client in the decision-making process. Moreover, the findings call for a greater collaborative environment between the construction team and quality management department, rather than being seen as obstructive (i.e. compliance based policing).

All of these must be driven by leadership to overhaul the way quality is managed on schemes. The findings demonstrate the importance and impact from open-ended survey response data studies to enhance quantitative outcomes, and help provide strengthened proposals of improvement.

There are limitations to this paper that require noting. Firstly, the survey was conducted within one principal contractor with varying levels of knowledge across multiple sectors. Secondly, the case study data was from a current major highways scheme, therefore the generalisability of the findings is limited for other sectors. Thirdly, the demographic

profiles of the participants were not analysed in this paper as to understand whether gender or hierarchy level play a part in the variance of opinions.

The recommendations for future research are to perform greater volumes of qualitative survey exercises over a wider range of contracting organisations, but with the addition of clients and supply chain to enhance the credibility of quality performance, and help to present a more rounded perspective of quality management. By undertaking consistent exercises across different sectors, we will be able to determine which sectors are struggling the most and allow leaders to offer greater support for improvement.

It is the author's intention to conduct further research into the demographic profiling of project professionals to help understand how gender and hierarchical positioning influence qualitative feedback, and address the gap in this study.

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Figure 1

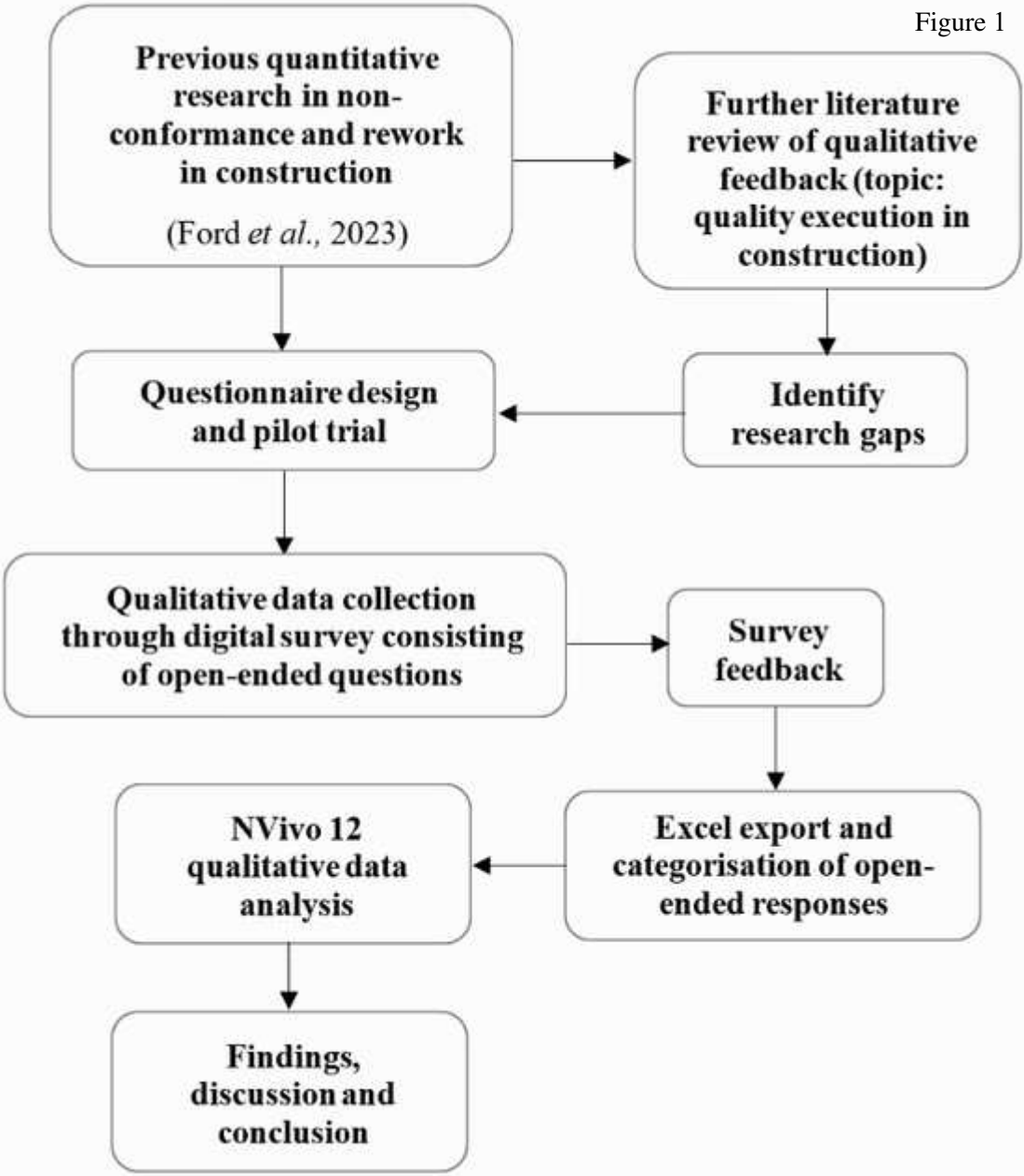

Previous quantitative research in non-conformance and rework in construction
(Ford *et al.*, 2023)
Further literature review of qualitative feedback (topic: quality execution in construction)
Identify research gaps
Questionnaire design and pilot trial
Qualitative data collection through digital survey consisting of open-ended questions
Survey feedback
Excel export and categorisation of open-ended responses
NVivo 12 qualitative data analysis
Findings, discussion and conclusion

Figure 2

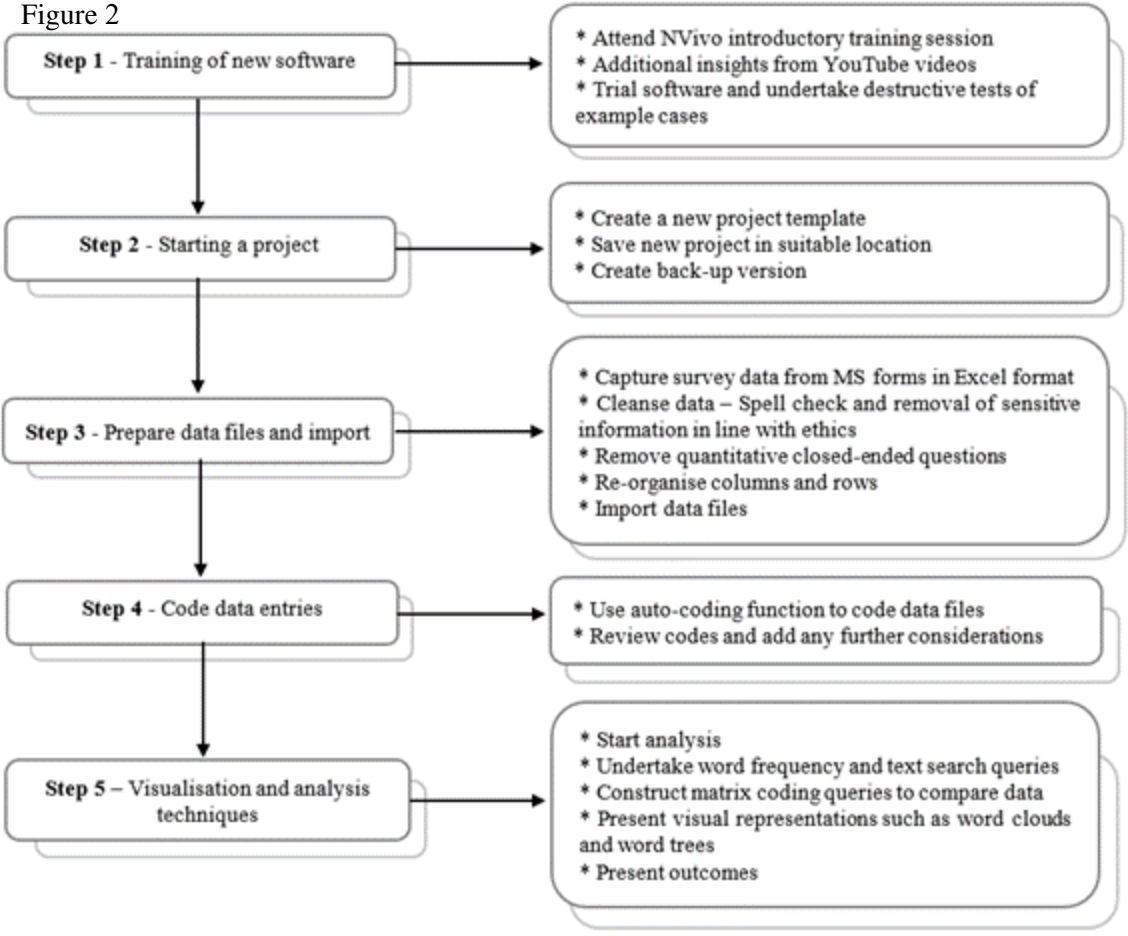

Step 1 - Training of new software
* Attend NVivo introductory training session
* Additional insights from YouTube videos
* Trial software and undertake destructive tests of example cases
Step 2 - Starting a project
* Create a new project template
* Save new project in suitable location
* Create back-up version
Step 3 - Prepare data files and import
* Capture survey data from MS forms in Excel format
* Cleanse data – Spell check and removal of sensitive information in line with ethics
* Remove quantitative closed-ended questions
* Re-organise columns and rows
* Import data files
Step 4 - Code data entries
* Use auto-coding function to code data files
* Review codes and add any further considerations
Step 5 – Visualisation and analysis techniques
* Start analysis
* Undertake word frequency and text search queries
* Construct matrix coding queries to compare data
* Present visual representations such as word clouds and word trees
* Present outcomes

Figure 3

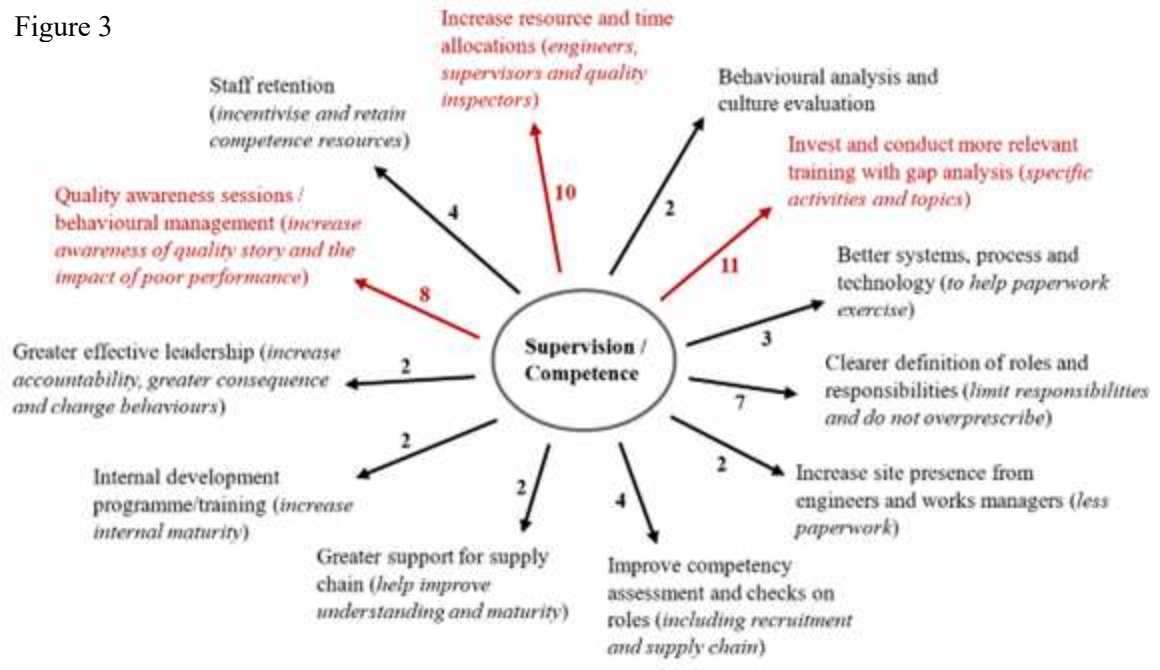

Supervision / Competence
Increase resource and time allocations (engineers, supervisors and quality inspectors)
10
Staff retention (incentivise and retain competence resources)
4
Behavioural analysis and culture evaluation
2
Invest and conduct more relevant training with gap analysis (specific activities and topics)
11
Quality awareness sessions / behavioural management (increase awareness of quality story and the impact of poor performance)
8
Better systems, process and technology (to help paperwork exercise)
3
Greater effective leadership (increase accountability, greater consequence and change behaviours)
2
Clearer definition of roles and responsibilities (limit responsibilities and do not overprescribe)
7
Internal development programme/training (increase internal maturity)
2
Increase site presence from engineers and works managers (less paperwork)
2
Greater support for supply chain (help improve understanding and maturity)
2
Improve competency assessment and checks on roles (including recruitment and supply chain)
4

Figure 4

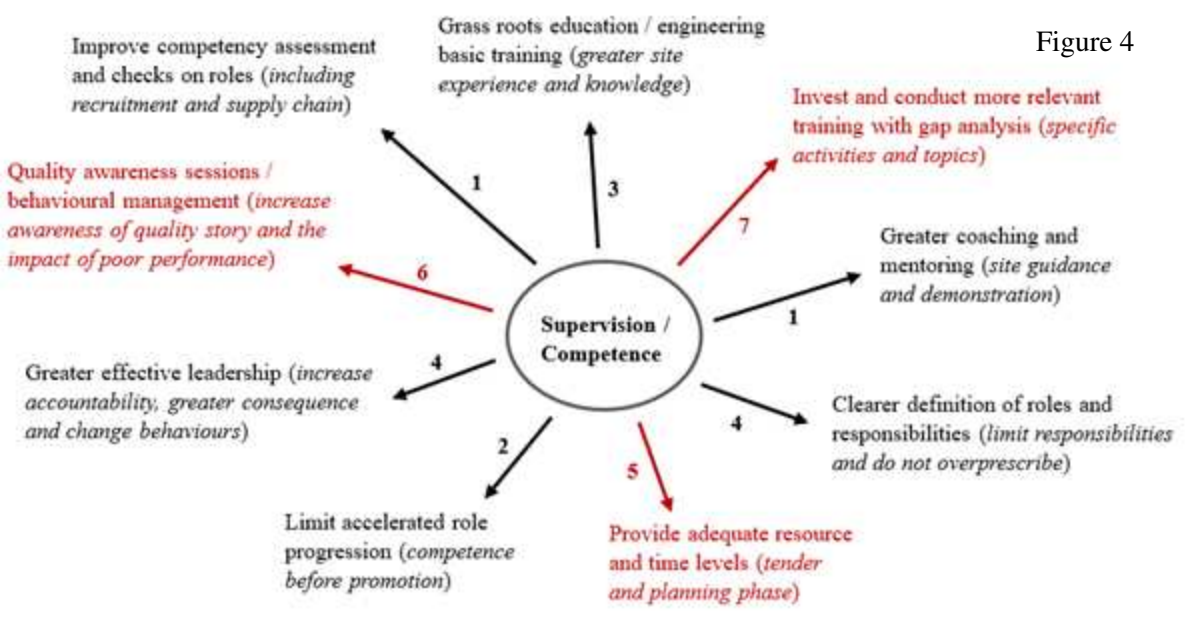

Improve competency assessment and checks on roles (including recruitment and supply chain)
Grass roots education / engineering basic training (greater site experience and knowledge)
Invest and conduct more relevant training with gap analysis (specific activities and topics)
Quality awareness sessions / behavioural management (increase awareness of quality story and the impact of poor performance)
Greater coaching and mentoring (site guidance and demonstration)
Supervision / Competence
Greater effective leadership (increase accountability, greater consequence and change behaviours)
Clearer definition of roles and responsibilities (limit responsibilities and do not overprescribe)
Limit accelerated role progression (competence before promotion)
Provide adequate resource and time levels (tender and planning phase)
1
3
7
6
1
4
4
2
5

Table 1 – Theoretical framing of rework in construction using Ford *et al.* (2023)

	Most prominent rework causes	**Most costly root cause classifications**	**Highways specific technical areas**	**Lessons learned**
Indicative Supporting Studies	Abdul-Rahman *et al.* (1996); Love (2002); Forcada *et al.* (2014); Ye *et al.* (2015); Oyewobi *et al.* (2016); Wuni and Shen (2020); Ford *et al.* (2023)	Abdul-Rahman *et al.* (1996); Love and Edwards (2005); Forcada *et al.* (2014); Wuni and Shen (2020); Love *et al.* (2022); Ford *et al.* (2023)	Taylor *et al.* (2012); Forcada *et al.* (2014); Ford *et al.* (2023)	Taylor *et al.* (2012); Wuni and Shen (2020); Love *et al.* (2020); Love *et al.* (2022); Ford *et al.* (2023)
Conclusions from Ford et al. (2023)	1) Materials Management 2) Workmanship / poor quality execution 3) Supervision	1) Workmanship / poor quality execution 2) Supervision 3) Materials Management	1) Structural concrete (*Series 1700*) 2) Drainage (*Series 500*) 3) Earthworks (*Series 600*)	- Accountability & consequence for quality - Resource planning and investment - Greater Leadership - SQEP vetting (*competency assessment*) - Improve managing materials through technology - Training in root cause analysis (RCA) techniques
Propositions and questions from previous study to current (Appendix II)	(Q17) Perceptions of primary root causes from industry professionals	(Q1 & Q2) Quality execution within principal contractor and supply chain (Q4) Cost perceptions of non-conformance and rework (Q8) Contractual arrangements of cost with designers	(Q21) Struggles with SQEP resources (Q25) Re-evaluation of insitu concrete operations (Q27) RECo panel construction risks	(Q7) Insufficient training in RCA techniques (Q9) Proceeding at risk without approved designs (Q15) Understanding of quality expectations (Q21) Struggles of SQEP resources (Q26) Supply chain cost vs performance selection

Table 2 – Survey respondent referencing

Contract Leaders			Quality Community		
ID	**Gender**	**Job Role**	**ID**	**Gender**	**Job Role**
CL01	Male	Project Director (Including Senior)	QC01	Male	Quality Manager (Including Senior)
CL02	Female	Project Manager (Including Senior)	QC02	Female	Head of Business Improvement
CL03	Male	Programme Director (Including Senior)	QC03	Male	Systems, Performance and/or Assurance Manager
CL04	Male	Programme Director (Including Senior)	QC04	Female	Quality Manager (Including Senior)
CL05	Male	Project Director (Including Senior)	QC05	Female	Systems, Performance and/or Assurance Manager
CL06	Male	Project Manager (Including Senior)	QC06	Male	Quality Manager (Including Senior)
CL07	Male	Project Manager (Including Senior)	QC07	Female	Quality Manager (Including Senior)
CL08	Male	Project Manager (Including Senior)	QC08	Male	Head of RDP(N) Integrated Management Office
CL09	Male	Programme Director (Including Senior)	QC09	Female	Completions Manager
CL10	Male	Project Director (Including Senior)	QC10	Male	Quality Manager (Including Senior)
CL11	Male	Programme Director (Including Senior)	QC11	Female	Quality Manager (Including Senior)
CL12	Male	Project Manager (Including Senior)	QC12	Female	Systems, Performance and/or Assurance Manager
CL13	Male	Project Director (Including Senior)	QC13	Male	Head of Technical Assurance
CL14	Male	Project Manager (Including Senior)	QC14	Female	Quality Manager (Including Senior)
CL15	Male	Project Director (Including Senior)	QC15	Male	Project Manager (Including Senior)
CL16	Male	Project Manager (Including Senior)	QC16	Female	Handover Manager (Including Senior)
CL17	Male	Project Director (Including Senior)	QC17	Male	Quality (Engineer / Inspector / Consultant / Coordinator / Practitioner)
CL18	Male	Project Manager (Including Senior)	QC18	Male	Project Director (Including Senior)
CL19	Male	Project Manager (Including Senior)	QC19	Male	Quality Manager (Including Senior)
CL20	Female	Project Manager (Including Senior)	QC20	Male	Handover Manager (Including Senior)
CL21	Male	Programme Director (Including Senior)	QC21	Male	Quality (Engineer / Inspector / Consultant / Coordinator / Practitioner)
			QC22	Female	Systems, Performance and/or Assurance Manager
			QC23	Male	Quality Manager (Including Senior)
			QC24	Male	Quality Director / Head of Quality / Business Improvement Manager
			QC25	Male	Quality Manager (Including Senior)
			QC26	Male	Quality (Engineer / Inspector / Consultant / Coordinator / Practitioner)
			QC27	Female	Quality (Engineer / Inspector / Consultant / Coordinator / Practitioner)
			QC28	Male	Quality Manager (Including Senior)
			QC29	Male	Quality Manager (Including Senior)
			QC30	Female	Quality Delivery Manager
			QC31	Female	Quality (Engineer / Inspector / Consultant / Coordinator / Practitioner)
			QC32	Male	Quality Manager (Including Senior)
			QC33	Female	Handover Manager (Including Senior)
			QC34	Male	Quality Manager (Including Senior)
			QC35	Male	Quality Manager (Including Senior)
			QC36	Female	Quality (Engineer / Inspector / Consultant / Coordinator / Practitioner)
			QC37	Male	Product Quality Manager/Materials Manager
			QC38	Male	Quality Manager (Including Senior)

Table 3 - Positives and negatives of proceeding without approved designs (Question 10)

Group	Word references	Positive and negative outcomes
Contract Leaders	10 references to 'design' 11 references to 'cost' 11 references to 'Programme' 9 references to 'Risk' 11 references to 'Work'	**Positives** • The project remains on programme • Critical path activities are not compromised • Reduces overhead (prelim) costs • Provides a continuing stream of work for supply chain • Delay costs and penalties often outweigh rework costs **Negatives** • Higher likelihood of defects and rework • Enhanced risks and responsibilities for the contractor not the designer • Scope creep (design becomes elongated) • Unstable programme without a defined design scope • Cost and time escalations due to protracted contract close out • Greater difficulty managing handover and contract completion • Commercial onslaught (mis-management allegations, commercial claims and potential loss of future work) • Drive a negative behaviour where proceeding at risk is acceptable which will continue on future schemes • Design changes through review processes as more information becomes available (e.g. ground investigation) • Further poor decision making as the true impact is not realised
		Standout quote (CL03): *"Time is often more expensive than rectification of defective works"*
Quality Community	20 references to 'design' 30 references to 'Work' 17 references to 'Rework' 10 references to 'Risk' 12 references to 'Costs'	**Positives** • Possibilities to meet or improve on programme pending sufficient risk review analysis • Time saving if no design change is required • Time and cost to carry out rework may be less impactful than waiting for design approval • Provides supply chain with a continued stream of work with limited downtime **Negatives** • Rework including wider re-design and site changes to fix • Quality outputs decrease (e.g. more defects) • Ambiguity of scope (i.e. building something that doesn't work) • Unforeseen design clashes on site • Cost escalations (delay damages and disallowed costs) • Failure to meeting target dates within programme • Commercial pain • Personnel implications of proceeding without approval • Affects relationships with clients and supply chain (arguments) • Reduces morale and confidence of work force • Increased safety issues • End product may not be what the client wants • Short term and long term reputational damage resulting in loss of work and alternative delivery partners
		Standout quote (QC15): *"There are no positives. In the end, it catches up with us. Use the safety analogy…Is it ok to have a quantity of accidents? No."*

Table 4 - Quality improvement areas suggested by two professional working groups (Question 20)

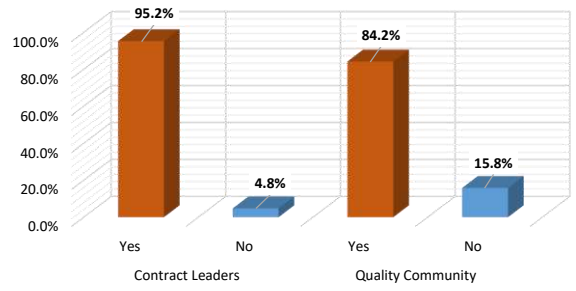
Group 1 – Contract Leaders		Group 2 – Quality Community	
Area for improvement	**Counts**	**Area for improvement**	**Counts**
Workforce competence (*training, education and coaching to SQEP level*)	12	**Workforce competence** (*training, education and coaching to SQEP level*)	16
Quality culture (*behaviours, accountability, incentivisation to appreciate and understand quality)*	8	**Materials Management** (*overall management of materials from manufacture through to installation*)	12
Supervision (*engineering and frontline supervision resource*)	4	**Supervision** (*engineering and frontline supervision resource*)	10
Leadership (*increased quality management mandate and clearer vision*)	4	**Quality culture** (*behaviours, accountability, incentivisation to appreciate and understand quality)*	10
Materials Management (*overall management of materials from manufacture through to installation*)	3	**Leadership** (*increased quality management mandate and clearer vision*)	9
Resource and planning (*review of engineering, supervision and quality resources on project, and plan for RFT*)	3	**Workmanship** (*address poor quality execution at project and company level including supply chain and designers*)	6
Collaboration (*breeding better collaboration with clients, designers and supply chain*)	1	**Resource and planning** (*review of engineering, supervision and quality resources on project, and plan for RFT*)	3
Standardisation (*more consistent off the shelf solutions rather than bespoke complex builds*)	1	**Supply chain procurement** (*greater vetting and performance evaluation of supply chain*)	2
		Standardisation (*more consistent off the shelf solutions rather than bespoke complex builds*)	1
		Change management (*adaptive change control not retrospectively*)	1

Appendix I. Closed-ended survey questions from Ford et al. (2023)

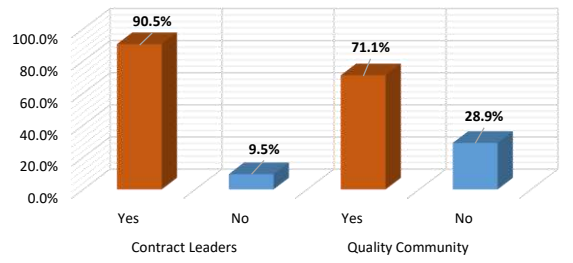
	Response rate	Interest Score
Contract Leaders	**31.3%**	**8.2**
Quality Community	**40.0%**	**9.1**

Q1: Do you see quality execution as a problem within the company?

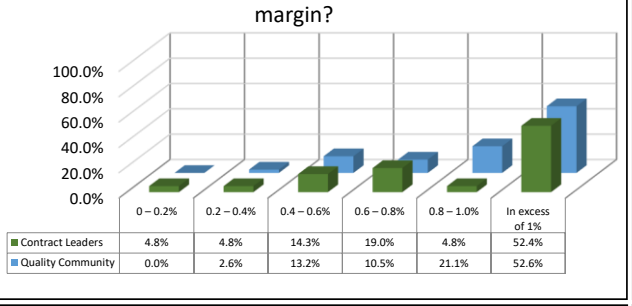
Q2: Do you see quality execution as a problem with our supply chain?



Q3: Are we at risk of post project completion latent defects causing long term profitability issues for the business?

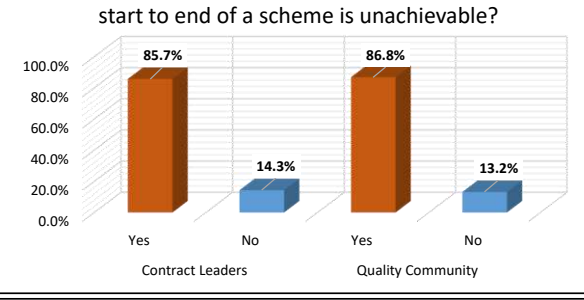


Q4: What do you believe the cost of nonconformance rectification was of a 3% profit margin?

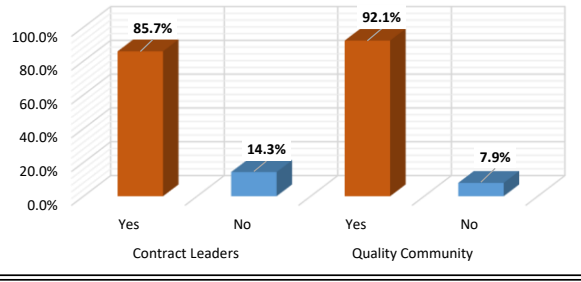


	0 – 0.2%	0.2 – 0.4%	0.4 – 0.6%	0.6 – 0.8%	0.8 – 1.0%	In excess of 1%
Contract Leaders	4.8%	4.8%	14.3%	19.0%	4.8%	52.4%
Quality Community	0.0%	2.6%	13.2%	10.5%	21.1%	52.6%

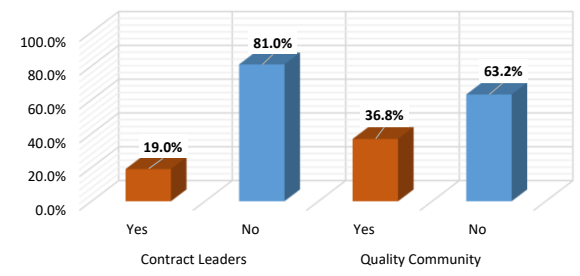
Q5: Is there an expectation that 'rework' in some form is inevitable and that 'right-first-time' from start to end of a scheme is unachievable?



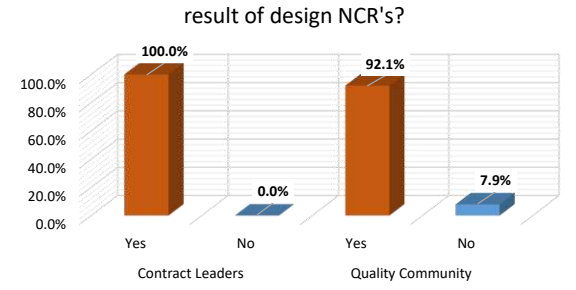
Q6: NCR problems are often 'oversimplified'. Do you agree?



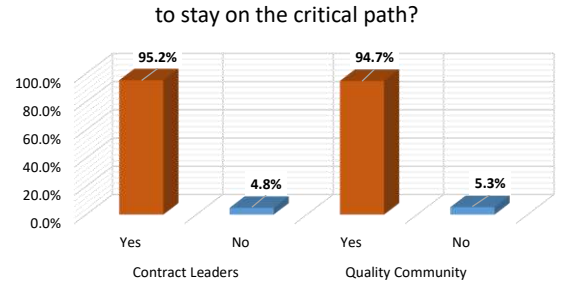
Q7: Are our team members who manage NCR's sufficiently trained in RCA techniques?



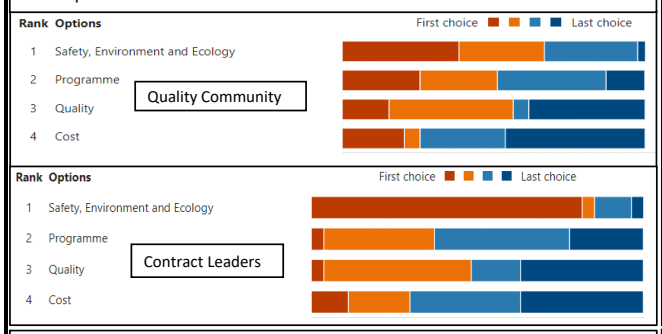
Q8: Should our contractual arrangements with designers be re-evaluated to apportion cost as a result of design NCR's?



Q9: Do we at times progress at risk without approved design details as a result of design delay to stay on the critical path?

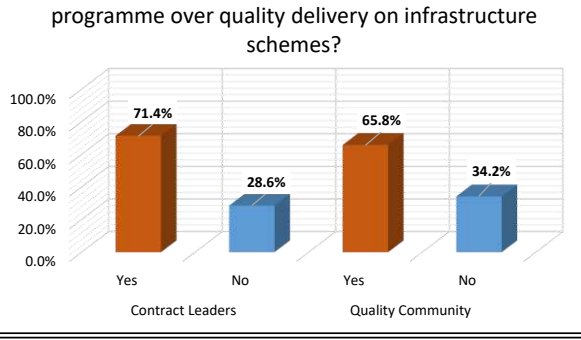


Q11: Rank SHE, Programme, Quality and Cost in priority order as you see it for delivery of complex construction schemes.

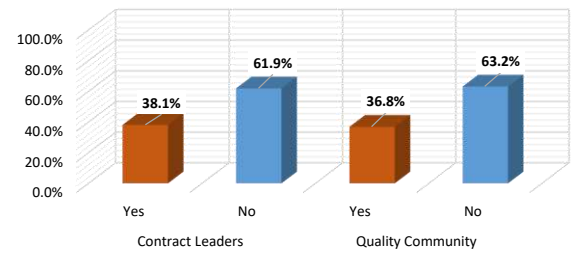


Q12: Do you believe cost and programme are treated as higher priority than quality delivery on our projects?

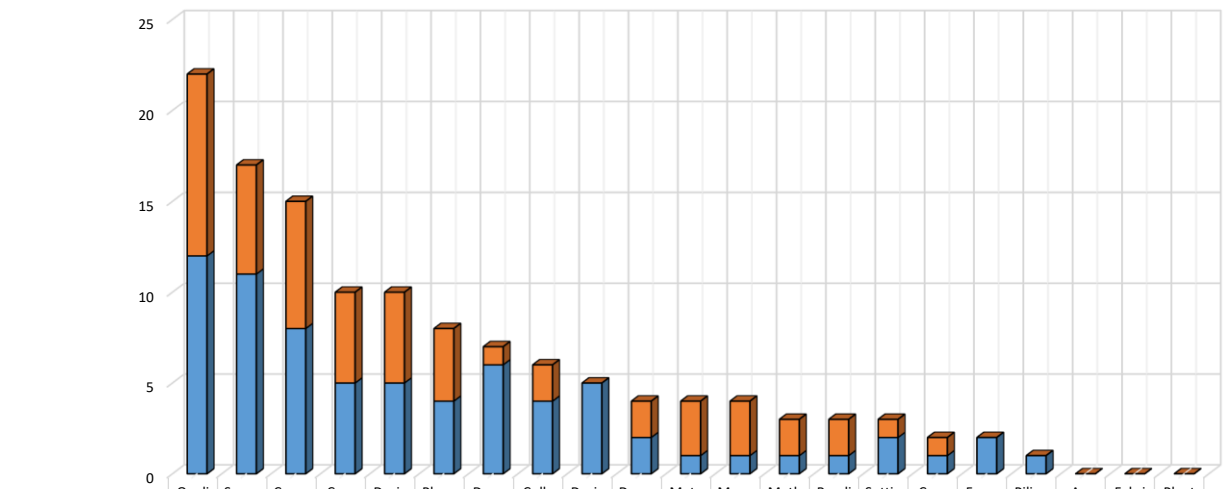
Q14: Do you think our clients value cost and programme over quality delivery on infrastructure schemes?



Q15: Do all parties on our project fully appreciate and understanding the level of quality to be achieved?

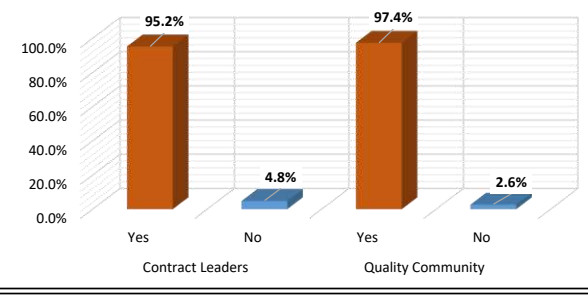


Q17: Which do you believe are the three most likely causes of nonconformance and rework?

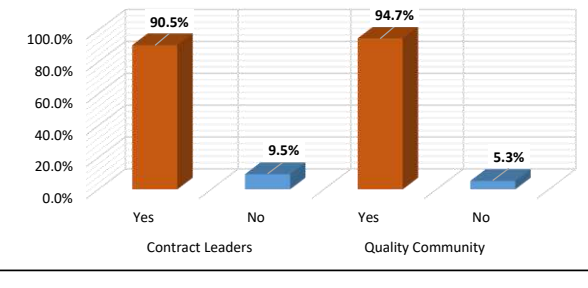


	Quality Execution/ Workmanship	Supervision issue	Competency/Training	Communication/Knowledge Transfer	Design	Planning / Sequencing	Documentation Issue	Collaboration	Design Management (PC)	Damage (Careless behaviour)	Materials Management	Management Issue	Methodology	Reading Design Information	Setting out	Commercial Issue	Formal system / Process	Piling Construction	As-built model	Fabrication Error	Plant /equipment
Contract Leaders	10	6	7	5	5	4	1	2	0	2	3	3	2	2	1	1	0	0	0	0	0
Quality Community	12	11	8	5	5	4	6	4	5	2	1	1	1	1	2	1	2	1	0	0	0

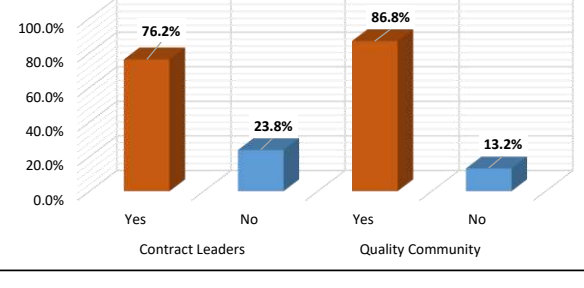
Q18: Based on a 3% profit margin and a potential profit loss of 17%, Is this figure of concern?



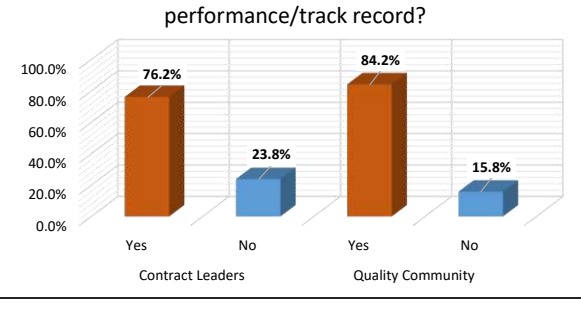
Q21: We are struggling with SQEP resource (E.g engineers, supervisors). Do you agree with this statement?

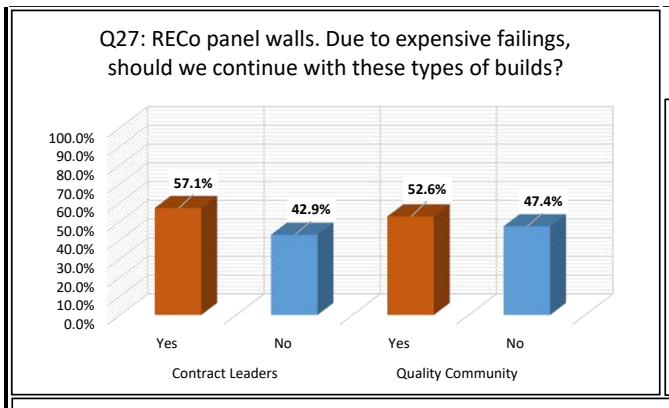


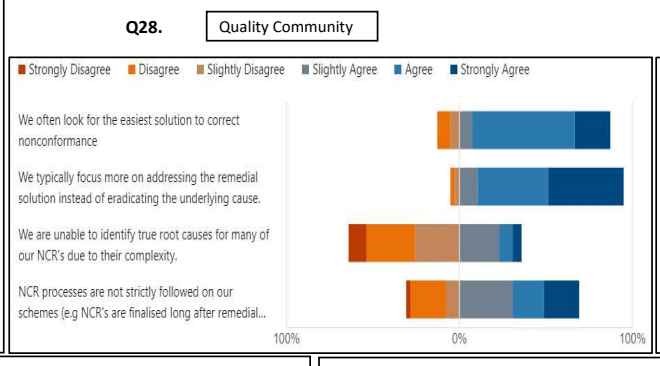
Q25: Should we re-evaluate our approach to insitu concrete operations? (e.g. precast)

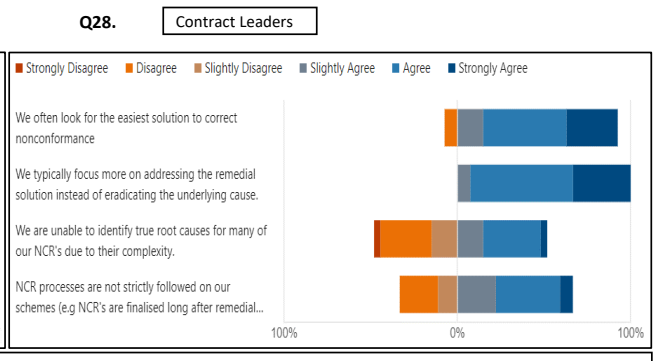


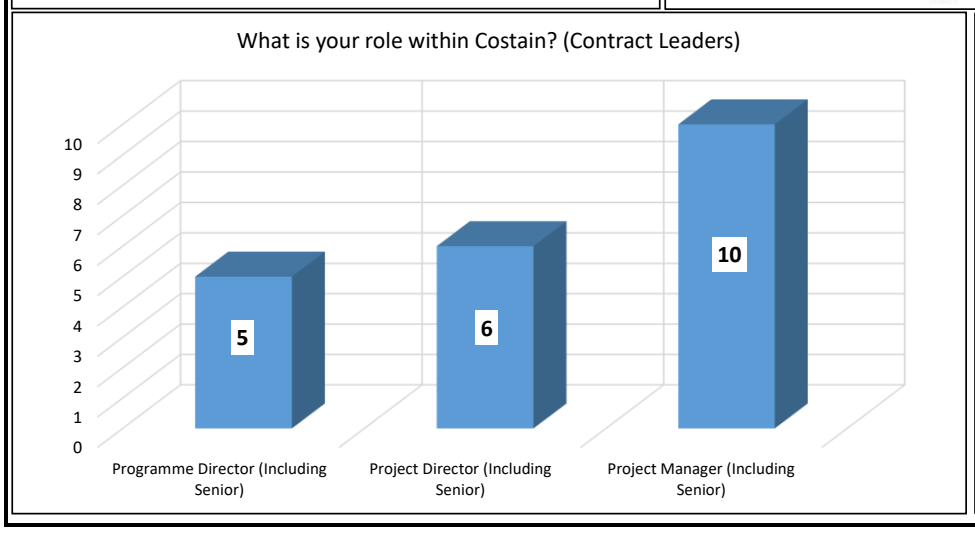
Q26: Are there concerns that typically we select supply chain primarily on price and not previous performance/track record?

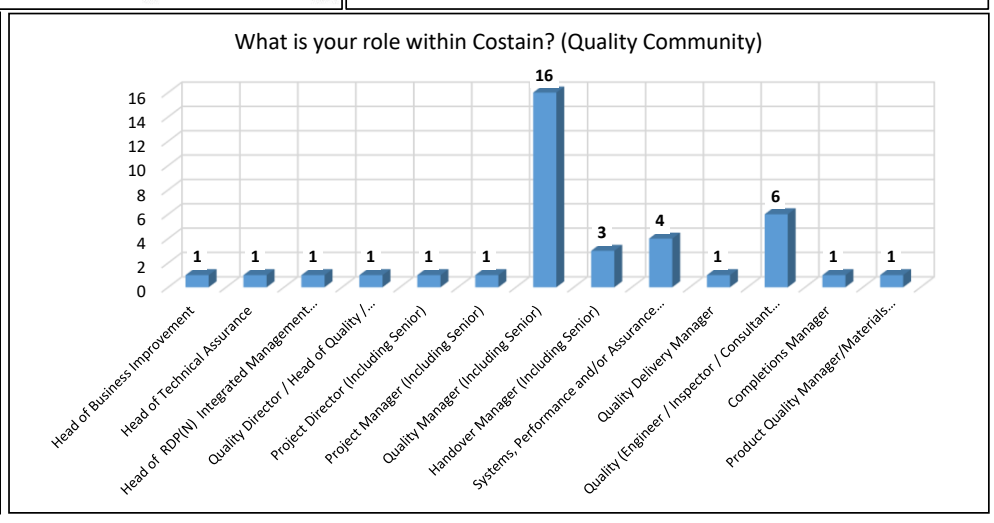



Q27: RECo panel walls. Due to expensive failings, should we continue with these types of builds?
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
57.1%
42.9%
52.6%
47.4%
Yes
No
Yes
No
Contract Leaders
Quality Community


Q28.
Quality Community
Strongly Disagree
Disagree
Slightly Disagree
Slightly Agree
Agree
Strongly Agree
We often look for the easiest solution to correct nonconformance
We typically focus more on addressing the remedial solution instead of eradicating the underlying cause.
We are unable to identify true root causes for many of our NCR's due to their complexity.
NCR processes are not strictly followed on our schemes (e.g NCR's are finalised long after remedial...
100%
0%
100%


Q28.
Contract Leaders
Strongly Disagree
Disagree
Slightly Disagree
Slightly Agree
Agree
Strongly Agree
We often look for the easiest solution to correct nonconformance
We typically focus more on addressing the remedial solution instead of eradicating the underlying cause.
We are unable to identify true root causes for many of our NCR's due to their complexity.
NCR processes are not strictly followed on our schemes (e.g NCR's are finalised long after remedial...
100%
0%
100%


What is your role within Costain? (Contract Leaders)
10
9
8
7
6
5
4
3
2
1
0
5
6
10
Programme Director (Including Senior)
Project Director (Including Senior)
Project Manager (Including Senior)


What is your role within Costain? (Quality Community)
16
14
12
10
8
6
4
2
0
1
1
1
1
1
1
16
3
4
1
6
1
1
Head of Business Improvement
Head of Technical Assurance
Head of RDP(NI) Integrated Management...
Quality Director / Head of Quality /...
Project Director (Including Senior)
Project Manager (Including Senior)
Quality Manager (Including Senior)
Handover Manager (Including Senior)
Systems, Performance and/or Assurance...
Quality Delivery Manager
Quality (Engineer / Inspector / Consultant...
Completions Manager
Product Quality Manager/Materials...

Appendix II – NVivo 12 word frequency summary and cloud for each open-ended survey question

QUESTION 10: What do you believe is the potential consequences for proceeding at risk without approved designs (Both positive and negative)?

Contract Leaders

Word	Length	Count	Weighted Percentage (%)	Similar Words
design	6	19	3.79	design, designer, designers, designs
costs	5	17	3.39	cost, costs
programme	9	14	2.79	programme
risk	4	12	2.40	risk
work	4	11	2.20	work, works

Quality Community

Word	Length	Count	Weighted Percentage (%)	Similar Words
design	6	41	4.43	design, designer
works	5	28	3.03	work, working, works
rework	6	21	2.27	rework, reworks
risk	4	17	1.84	risk, risks
costs	5	15	1.62	cost, costs

Question 13 – Do you think that cost and programme are more important than quality delivery? Please explain.

Contract Leaders

Word	Length	Count	Weighted Percentage (%)	Similar Words
costs	5	27	5.13	cost, costly, costs
quality	7	26	4.94	quality
programme	9	15	2.85	programme
works	5	10	1.90	work, working, works
time	4	9	1.71	time, time', timing

Quality Community

Word	Length	Count	Weighted Percentage (%)	Similar Words
quality	7	44	5.58	quality
cost	4	35	4.44	cost, costs
programme	9	29	3.68	programme, programmes
time	4	19	2.41	time, time'
project	7	16	2.03	project, projects

Question 16 – Do all parties on our project fully appreciate and understanding the level of quality to be achieved? If 'No', why do you believe this is the case?

Contract Leaders

Word	Length	Count	Weighted Percentage (%)	Similar Words
client	6	7	3.06	client, clients
quality	7	6	2.62	quality
standard	8	6	2.62	standard, standards
different	9	5	2.18	different
often	5	5	2.18	often

Quality Community

Word	Length	Count	Weighted Percentage (%)	Similar Words
client	6	17	3.73	client, clients
expects	7	14	3.07	expect, expectations, expected, expects
quality	7	13	2.85	quality
project	7	10	2.19	project, projects
time	4	10	2.19	time, times

Question 19 – Analysis of 1260 nonconformances indicates rework costs of 0.5% of the total project value (£7,739,850). Is this figure of concern? Please explain your answer.

Contract Leaders

Word	Length	Count	Weighted Percentage (%)	Similar Words
cost	5	16	3.90	cost, costs
profit	6	11	2.68	profit, profitability
margin	6	7	1.71	margin, margins
quality	7	7	1.71	quality
work	4	7	1.71	work, working, works

Quality Community

Word	Length	Count	Weighted Percentage (%)	Similar Words
cost	5	31	4.82	cost, costs
project	7	16	2.49	project, projects
profit	6	14	2.18	profit, profits
rework	6	13	2.02	rework, reworks
loss	4	11	1.71	loss, losses

Question 20 – The most frequent NCR root causes were found to be materials management, poor workmanship and supervision. What do you believe we should focus on to prevent repetition of future schemes? Please list.

Contract Leaders

Word	Length	Count	Weighted Percentage (%)	Similar Words
quality	7	15	3.01	quality
management	10	10	2.01	manage, managed, management, managers, managing
engineering	11	8	1.61	engineering, engineers
materials	9	8	1.61	material, materials
right	5	8	1.61	right

Quality Community

Word	Length	Count	Weighted Percentage (%)	Similar Words
quality	7	35	3.18	quality
materials	9	24	2.18	material, materials
work	4	20	1.82	work, working, works
supervision	11	19	1.73	supervise, supervising, supervision
management	10	16	1.45	manage, management, managers, managing

Question 22 – You've selected 'Yes' to the previous question. There were 137 cases of poor/lack of supervision and a further 26 cases of competency/training issues notified via non-conformance reports. What do you believe the solution to be?

Contract Leaders

Word	Length	Count	Weighted Percentage (%)	Similar Words
quality	7	17	3.59	quality
engineers	9	15	3.17	engineer, engineering, 'engineering', engineers
training	8	11	2.33	train, training
managers	8	7	1.48	management, managers
work	4	7	1.48	work, worked, working, works

Quality Community

Word	Length	Count	Weighted Percentage (%)	Similar Words
engineers	9	26	3.78	engineer, engineering, engineers
quality	7	17	2.47	quality
works	5	16	2.33	work, worked, working, works
training	8	13	1.89	train, training
project	7	12	1.75	project, projects