




Effects of adopting mobile technologies on the managerial competencies of construction firms

**Authors:**Thabo J. Lesebo¹ Patient Rambe¹ Takawira Ndofirepi¹ **Affiliations:**

¹Department of Business Support Studies, Faculty of Management Sciences, Central University of Technology, Bloemfontein, South Africa

Corresponding author:

Thabo Lesebo,
thabo.lesebo@gmail.com

Dates:

Received: 24 Oct. 2022

Accepted: 20 Feb. 2023

Published: 26 Apr. 2023

How to cite this article:

Lesebo, T.J., Rambe, P. & Ndofirepi, T., 2023, 'Effects of adopting mobile technologies on the managerial competencies of construction firms', *South African Journal of Information Management* 25(1), a1627. <https://doi.org/10.4102/sajim.v25i1.1627>

Copyright:

© 2023. The Authors.
Licensee: AOSIS. This work is licensed under the Creative Commons Attribution License.

Read online:

Scan this QR code with your smart phone or mobile device to read online.

Background: The extensive utilisation of mobile technologies (MTs) for cost reduction and improving organisational efficiency is widely acknowledged in the entrepreneurship literature. Despite the fact, the effect of adopting MTs on the managerial competencies of small, micro and medium enterprises (SMMEs) remains incomprehensible by emerging construction firms (ECFs).

Objectives: This study contributes to the theory and practise of competency development in project management (PM) by exploring how MT adoption intensity during project execution affects the perceived managerial competencies of owners/project managers of ECFs.

Method: This quantitative study employed the perspectives of 222 ECF owners/managers surveyed in the Free State province of South Africa. It established how the adoption of MTs during project execution impacted the perceived managerial competencies of these entrepreneurs.

Results: The results indicated that the adoption of MTs during project execution has a positive and significant effect on the communicative and social competencies of ECF owners and managers, with MT adoption explaining 88.0% of the variance in communicative competencies and 87.9% in social competencies. The results further demonstrate that the type of device used (laptops and tablets) moderated the strength of the MT adoption – managerial competencies relationship.

Conclusion: The study recommends targeted and strategic wider rollout of specific MTs that improve managerial competencies to optimise the efficiency of project-related operations.

Contribution: The article contributes to the broader PM theory and literature especially competency-based project execution by exploring how MT adoption can facilitate greater communication and social competencies that improve the organisational efficiency of ECFs.

Keywords: mobile technologies; project execution; managerial competencies; emerging construction firms; project management.

Introduction

The literature demonstrates the prevalence of the adoption of mobile technologies (MTs) in project management (PM) (Martínez-Rojas, Marín & Vila 2016; Olaniyan 2019; Parikh, Mody & Pitroda 2021). It is consistently argued that, in the management of construction projects, MTs bring multiple benefits, ranging from shorter project timelines (Parikh et al. 2021) and more efficient use of materials to facilitate better coordination of employees, suppliers and stakeholders, among other benefits (Alaloul, Liew & Zawawi 2016; Olaniyan 2019). A variety of MTs have also been adopted, specifically during the implementation stages of activities such as project monitoring, infrastructural repair and/or erection of construction structures; checking the progress of projects in real time and quality control; workplace safety audit and communicating issues of assessment and resolution (Bajwa 2022; Holtmann 2019; Sattineni & Schmidt 2015). Despite this wider use, what has not been empirically tested in PM literature is whether the exploitation of MTs during project execution enhances the managerial competencies of the PM team. Thus, there is a lack of clarity in the literature regarding the impact of the use of different MTs in PM processes especially project execution on the development of managerial competencies in PM teams. For instance, research conducted by Olaniyan (2019) on barriers to technology adoption among construction project managers suggests that adequate financial investment and appropriate technology training are necessary for construction project managers to engage in the adoption of such technologies. Despite the potency of this study regarding the valence of technology adoption in project success, more insights are needed pertaining to whether different technologies exert the same or different effects on the competencies of such managers operating

in the same environment. Additionally, it is unclear whether the extent of use of a specific instance of MT can impact these competencies in similar or different ways. Research has remained inconclusive on whether the use of a specific MT (e.g. laptop computer or tablet) at the expense of another (e.g. mobile phone) could enhance particular managerial competencies differently (Correa, Pavez & Contreras 2018; Olaniyan 2019).

Given this grey area in the literature, the study sought to address the following research questions:

1. To what extent does the adoption of MTs during project implementation processes impact the managerial competencies of PM teams?
2. Does the choice of specific MT moderate the relationship between the use of MTs during project implementation processes and the realisation of managerial competencies?

This study makes two main contributions. Firstly, it demonstrates the competencies that can be readily activated by adopting MTs during project execution. Secondly, it contributes to an understanding of the specific types of technologies that are most germane to the project execution phase (PEP) and therefore, could be leveraged to impact managerial competencies effectively. Such contribution is timely given the louder calls for emerging technologies to be more relevant to their context of use (Correa et al. 2018; Olaniyan 2019) and to generate more social impact at different stages of the project cycle (Olaniyan 2019).

Literature review

The appropriation of MTs during project execution involves the connections of different stakeholders in the project cycle (Project Management Institute [PMI] 2017; Rasiah 2019) and stimulates the exchange of different resources and capabilities across different nodes (persons) and networks (Rasiah 2019). Therefore, Connectivism provides a pertinent theoretical lens for unpacking the connection between technologies in use, the agents who deploy such technologies, and the strengthening of the competences in unique understudied contexts. Connectivism is a theory of learning that emphasises the value of learning networks as an integrated whole of connections and nodes (Goldie 2016; Siemens 2005). Thus, the appropriation of MTs during project execution can be leveraged to construct connective learning environments that capture knowledge in an effective and efficient manner, thereby enhancing competences of project teams. One would assume that project contractors, project managers and site workers engage in continual learning about projects under construction as they share, exchange and exploit different informational resources, data and project advice, facilitated by emerging technologies such as MTs. According to Connectivism, to the extent that these connections are representations of knowledge, learning is poised to occur as interactants interact and engage within and via MTs and networks (Hendricks 2019; Siemens 2017). Through the adoption of multiple MTs and platforms, different forms of knowledge are exchanged that engender the development of

capabilities such as creativity and collaboration. For instance, Siemens (2017) acknowledges that MTs, such as mobile phones, facilitate digital literacy and increasingly shape interactions between individuals and professionals. When interactions between site managers, contractors, site workers and senior managers are enabled and facilitated by networked technologies (e.g. mobile devices and platforms), this networked community is afforded the opportunity to make connections between site-based information and technical drawings (Rasiah 2019; World Economic Forum 2016). Given that Internet-connected devices enable access to search engines, electronic resources and project-based data, the effective use of such technologies for project initiation, team-based collaboration and simulations of project activities provides a direct and instant way for project managers, site teams and other project stakeholders to exchange knowledge relevant for the development of managerial competencies (Morrison-Smith & Ruiz 2020; Olaniyan 2019).

The use of MTs by emerging construction firms (ECFs) can be viewed as a means of enhancing the firm's organisational capabilities. For instance, Vial (2019) observes that digital technologies enable more information computing, communication and connectivity. They enable new forms of collaboration among distributed networks of diverse actors. Therefore, MT is used by construction firms as a means of facilitating the firm's inter-organisational collaboration, which has the potential to enhance the competencies of project teams. One can argue that the use of MTs facilitates and enhances the flow of project information among project stakeholders and ensures the project team's continuous collaboration with external and internal project stakeholders. This observation is consistent with Connectivism's postulation that knowledge and expertise are best disseminated in a ubiquitous manner (Grundmann 2016; Vial 2019).

While Connectivism provides a useful framework for unravelling how networks facilitated by technology enable the flow of resources within a PM ecosystem, the theory fails to distinguish resources internal and external to the organisation. It also fails to elucidate understanding on which combination of resources gives effect to greater and efficacious deployment of competences and hence the need for a complementary theory. Given the centrality of organisational resources (expertise, competencies, financial resources and network-based knowledge) in the implementation of projects, it is undeniable that the resource-based view (RBV) (Barney 1991; Greve 2020; Müller, Drouin & Sankaran 2019) can complement Connectivism in demonstrating how the exploitation of resources within and at the boundaries of firms can contribute directly to improving the managerial competencies of PM stakeholders. The application of RBV to PM operations can be explained by the importance of identifying organisational and project-specific resources (Müller et al. 2019) by PM stakeholders for the effective execution of projects through leveraging existing and potential capabilities within the project and its environment (Greve 2020; Müller et al. 2019). Therefore, the RBV complements the Connectivism theory as research

seeks to better understand the effect of using MTs on perceived managerial competencies during project execution. For instance, managers' perceptions about project performance may be related to the resources (including competencies and physical resources) availed to them for project implementation.

Mobile technologies

As effective PM necessitates the implementation of projects of the right quality at a reasonable cost, the challenges faced by construction managers/project managers on-site (such as the timely collection and sharing of real-time information on-site) necessitate the development of tools equipped with suitable sensing and communicating capabilities to acquire and exchange construction information efficiently (Bedard 2019; Park, Kim & Cho 2017; Yanes 2019). Park et al. (2017) hold the view that the advent of smartphones, coupled with mobile computing technology (such as tablets, laptops, etc.), personal digital assistant (PDA) technology, wireless communication technology, and radio frequency identification (RFID) technology, provides construction engineers and project managers with unprecedented opportunities to improve the existing processes of on-site construction management. Mobile technologies are harnessed to develop collaborative PM platforms and for collecting and sharing real-time site information and for optimally using 3-D sensing technologies. Such technologies have the potential to substantially improve on-site management processes and generate a new breed of knowledge workers (Park et al. 2017). This provides a good case for unravelling what role the domestication and appropriation of MTs within project execution contexts play in the acquisition of managerial competencies.

The development of a mobile learning research community has demonstrated its potential to enhance, extend and enrich the concept and activity of learning itself, beyond earlier conceptions of learning (Traxler, Barcena & Laborda 2015). If learning is enabled using MTs, the capacity of such technologies to foster learning communities creates a germane context for PM stakeholders to augment their opportunities for developing their managerial competencies through knowledge exchange and articulation. Traxler et al. (2015) posit that MT enhances areas such as contingent learning or agile learning, collaborative learning, context-aware learning and authentic learning to mention a few (Redden, Collin & Kim 2017). Therefore, the adoption of MT in the construction industry and PM community has immense potential to improve context-aware learning of construction managers/project managers on-site as much as it can enhance their competencies in effectively managing projects.

Adoption and integration of mobile technologies into the project execution phase

The development of PM theories concerning the adoption and use of MTs in construction projects is rooted in three interrelated but distinct perspectives: experience theory, ethnomethodology and Systems Theory (Bedard 2019;

Fioravanti et al. 2018). For instance, while experience theory targets the nature of construction-related activities for which the use of MTs is most relevant, ethnomethodology is premised on how people use MTs in the field and prioritises the observation of how people typically engage with MTs, which necessitates efficient and effective communication systems enabled by handhelds. Similarly, the Systems Theory emphasises that multiple people, events, objects and technologies are interdependent for any MT use to be successful, which points to the relevance of MT adoption and use in construction projects. As the successful construction of a project requires a determination of the tasks and resources for building the project as defined by the design team, MTs are useful in determining which of those activities are being performed and in which sequence to deliver on the required project objectives effectively and efficiently.

Therefore, the use of MTs provides a suitable framework for decision-makers and planners to source, apply, and better utilise PM knowledge and information to improve their organisation's productivity, profitability, and PM processes (especially project execution).

The PEP is the third phase in the project life cycle, and it is the phase where project deliverables mapped out in the PM plan, are developed and completed (PMI 2017). In this phase, according to PMI (2017), there are a series of processes that are performed that assist the project manager to understand whether the project will be a success or a failure. These processes include: (1) project cost management process (CMP), (2) quality management process (QMP), (3) risk management process (RMP), (4) procurement management process (PMP), and (5) communication management process. For this study, only these five processes will be explored as components that make up the PEP. Furthermore, the study will explore the extent to which the use of MTs in this phase impacts the managerial competencies of project managers/owners of ECFs. Although human resources, equipment and computer-based software are key requirements during the procurement stages of project execution (Watt et al. 2014), other components of project execution such as communication management process can unfold with considerably less resources if facilitated by readily available technologies such as social media platforms such as WhatsApp.

The project CMP is an amalgamation of processes involved in estimating, budgeting and controlling the costs of projects to ensure that they are completed within the approved budget (Larson & Gray 2017; PMI 2017). The high computerised power of mobile devices such as smartphones can be exploited for the calculation of quantities of raw materials and labour costs (Hynes 2021; Modern Contractor Solutions 2019). Thus, the adoption and integration of MTs can facilitate the estimation of project costs by calculating the available materials, labour hours and to project cost overruns. This dovetails with approximating the ultimate job prices and costs (PMI 2017). For construction project managers, in small-scale projects, this means that smartphones can expedite their work by calculating material quantities and

labour hours needed for a project including potential job cost breaks.

The project QMP is the process of ensuring that all project activities necessary to design, plan and implement a project are effective and efficient concerning the purpose they serve and their performance (Pm4dev.com 2019; PMI 2017). A holistic approach to managing quality in projects relies significantly on the satisfaction of direct customers, recurrent customers and affected stakeholders (Carruthers 2008; PMI 2017). Therefore, the philosophy of doing the right things should precede the actions of doing things right, thus achieving both effectiveness and efficiency. For construction project managers, this means that the adoption and integration of MTs into the QMP would provide the necessary environment for project transformation, enabling managers to systematically address their primary stakeholders' needs through advanced communication methods and tools such as online collaboration platforms and real-time feedback from stakeholders.

The RMP entails processes of risk management planning, risk identification, performing quantitative and qualitative risk analysis, risk response planning, risk response implementation and risk response monitoring during a project's lifecycle to keep the project on track and target (Kendrick 2015; Larson & Gray 2017; PMI 2017; Wadei 2019). Proactive risk management throughout a project's various phases exerts a significant impact on the project's outcomes such as ensuring that the technology selected delivers what is desired and validating the design to ensure consistency with project stakeholders' expectations. The strength of risk management lies in enumerating risks (both positive and negative) and focusing the project team on handling the risks that emerge. The use of MTs could enable project managers to optimise efficiency by enhancing planning and decision-making elements at each stage of project execution. Thus, the adoption of MTs and aligning them to the enhancement of managerial competencies of ECFs' managers could reduce project operational costs and maximise project managers' ability to enhance the quality of their risk management practises.

The term 'project procurement management process' refers to the processes of acquiring inputs, services or results from sources other than the project (PMI 2017). As such, procurement management requires control functions and automation tools to support the procurement and management of subsequent procurement actions associated with projects. For instance, the project manager can advertise for tenders, select the best offers and manage suppliers, conduct necessary audits and manage delivery schedules. Likewise, the adoption of MTs in the procurement process provides project managers with configurable, mobile-enabled, real-time information management solutions for tracking and managing procurement activities in general (PMI 2017). For construction project managers, employing real-time intelligence and automation tools to improve the

time and cost-effectiveness of their procurement decisions would be key to effective project delivery.

The communications management process (CoMP) involves planning, managing and monitoring communications during the project's life cycle (PMI 2017). The importance of communication in PM is widely recognised as critical to the success of construction projects (Hoadley 2019; PMI 2017). During construction activities, information such as purchasing details for equipment and building materials, budgets and approvals, digital drawings and construction plans need to be communicated between and among project stakeholders. Furthermore, MTs can purvey industrial information systems that reduce the time and effort required by project teams and stakeholders to communicate during a construction project. Moreover, successful project execution necessitates collaboration between construction workers, supervisors, architects, managers and even external stakeholders. As a result, the adoption and integration of MTs are critical in ensuring effective and efficient communication across all parties involved in the project. Therefore, the adoption of MTs for ECFs is expected to provide them with the resources necessary to perform their responsibilities in effectively managing construction projects.

Managerial competencies

There is contestation among scholars regarding the definition of competency and competence. Dubois' (2002) definition of competency is more detailed: a competency is any characteristic or trait that an individual uses for successful or exemplary performance. The 'performance tools' include an individual's knowledge, skills, thought patterns, mindsets, social roles, values, self-esteem and self-efficacy. A characteristic or trait is a competency only when its use can be proven to be necessary for the successful performance of a particular job, task or specific activity. Competencies involve behaviours that contribute to the successful management of specific activities and, ultimately, contribute to improved business performance (Arditi, Gluch & Holmdahl 2013; Makhalemele 2016; Rambe 2018). Managerial competencies, therefore, describe actual personal expressions and articulations of actions, behaviours and interpersonal interaction, such as active management, coordination, planning or motivation and outcomes relevant to the job (Makhalemele 2016; Rambe 2018; Ribeiro, Amaral & Barros 2021). Although there is a vast array of managerial competencies relevant to project execution, the managerial competencies postulated to be most influenced by the adoption of MTs during the PEP are social and operational competencies, particularly communicative competencies (Irfan et al. 2021).

Managerial competencies place their emphasis on a specific job position and how to carry out such a job of operational nature successfully (Light & McNaughton 2014; Rambe 2018; Ribeiro et al. 2021). According to Light and McNaughton (2014), the knowledge and skills in the use of social and strategic competencies reflect functional knowledge and

judgement in interaction. They regard communicative competencies as a relative and dynamic, interpersonal construct based on the functionality of communication, adequacy of communication and sufficiency of knowledge, judgement and skill. Communicative competencies can be project related as much as they are business related (i.e. most communication skills are common for general management and PM). During project execution, the role of a project manager is, not only, to direct and manage project execution, perform quality assurance, acquire the project team, develop the project team and manage the project team but also to distribute information in ways that manage stakeholder expectations and facilitate procurement processes (PMI 2017). Therefore, it can be argued that one of the competencies of a project manager should be communicative competency.

Social competencies reside in effectively building social networks and rapport with diverse people through leading change and building effective teams (Bradberry & Graves 2005; Larson & Gray 2017; Popkova & Zmiyak 2019). Popkova and Zmiyak (2019) and PMI (2017) have also considered influencing others (by applying power skilfully and cautiously while thinking of long-term collaboration), orientation to the customer, and political and cultural awareness as additional social competencies appropriate for use to effectively assist a project manager in managing the project. Therefore, it is very critical for a project manager to possess these qualities during project execution as Larson and Gray (2017) conceive project managers as systems thinkers that must consider the implications of their actions on diverse stakeholders in the PM ecosystem. Therefore, these managers must harness a holistic reductionist approach to projects (i.e. the ability to manage, plan, and coordinate all aspects of the project in a unified and integrated manner). Given that effective communication and smooth operations are integral to successful project execution, it is logical to argue that project managers can tap into communicative gadgets, tools and applications such as MTs in facilitating communications and operations on and off the site. Therefore, the domestication and exploitation of such technologies could contribute to the advancement of the social and communicative competencies of the project manager.

Research methodology

Research design and data collection procedure

The study adopted the positivist paradigm and quantitative research approach to investigate the influence of the adoption of MTs during project execution on perceived managerial competencies (i.e. owners' or managers' self-construction of their competencies) of ECFs. The quantitative approach was ideal as this research strives to establish associative and predictive relationships between variables based on numerical computations. A cross-sectional survey was conducted on small, micro and medium enterprises (SMME) owners or managers of ECFs in the construction industry located in the Free State province in South Africa. The Free State province is one of the provinces in South Africa with a high concentration of ECFs and therefore formed a relevant

context for the study. A sample size of 300 owners and managers was extracted from the Construction Industry Development Board (CIDB)-listed firms using a probability-based sampling technique to serve as the sampling frame.

A structured questionnaire that consisted of closed-ended questions served as the data collection tool. The questionnaire comprised four sections that elicited data on personal demographics, the use of MTs by the owners and managers, the use of MTs during the project execution processes and managerial competencies. The use of MTs variable was measured using a dichotomous questions scale adapted from PMI's (2017) project management body of knowledge (PMBOK). The use of MTs for project execution processes variable was measured using a five-point Likert item scale adapted from PMI's (2017) PMBOK. Lastly, five-point Likert item scales adapted from McCroskey and McCroskey's (1988) study were used for the managerial competencies variable.

The questionnaires were administered via an online platform, Question Pro. The target duration for completion of online questionnaires was 6 weeks from the date of distribution even though it was extended to 12 weeks because of the slow pace of responses. Of the 300 questionnaires that were distributed, 222 were returned to the researchers, thus representing a response rate of 74%.

Before conducting the study, the researchers obtained ethical clearance from the Department of Business Support Studies' Department Research and Innovation Committee (DRIC) and the Faculty Research and Innovation Committee (FRIC).

Data analysis procedure

Confirmatory factor analysis (CFA) and path analysis were used on the collected data to address the research questions/hypotheses. The analysis was carried out using the Jamovi computer software. Confirmatory factor analysis is a multivariate statistical test used to determine how well measurement items represent the number of constructs. In other words, it assesses the validity of a measurement model. Path analysis, on the other hand, is a statistical technique that is used to assess the influence of a set of predictor variables on a specific outcome variable. It is mostly used in determining the fitness of a structural model to the data when multiple causal pathways are involved.

Analysis of data and presentation of results

Respondents profile

Most of the 222 respondents were male ($n = 129$; 58.1%), aged between 15 and 54 years ($n = 189$; 85.1%), black South Africans ($n = 176$, 79.3%), held a matric qualification as a minimum qualification ($n = 193$; 87%), possessed an apprenticeship or short-course or undergraduate level of education in construction ($n = 186$; 83.8%). They had some business training ($n = 126$; 56.8%), operated private companies ($n = 91$;

41%), had 1 and 2 CIDB contractor grades ($n = 89$; 40.1%), and had been in the business for 5–15 years ($n = 153$; 68.9%).

Reliability and validity

The constructs were tested for construct reliability and content validity before being used to test the proposed hypotheses. The Cronbach alpha coefficient and average variance extracted (AVE) values for each construct are shown in Table 1 as evidence of the construct reliability and validity test results. Acceptable reliability is confirmed for any construct when its Cronbach alpha value is at least 0.7. When the factor loadings for each item measuring a construct are at least 0.5 and the AVE is at least 0.5, construct validity is

TABLE 1: Reliability and construct validity.

Factor	Indicator	Estimate	Cronbach alpha (α)	Average variance extracted
Social competencies	Q59	0.948	0.981	0.839
	Q60	0.926	-	-
	Q61	0.915	-	-
	Q62	0.928	-	-
	Q63	0.927	-	-
	Q64	0.924	-	-
	Q65	0.887	-	-
	Q66	0.875	-	-
	Q67	0.919	-	-
	Q68	0.918	-	-
Communicative competencies	Q44	0.938	0.977	0.807
	Q45	0.893	-	-
	Q46	0.920	-	-
	Q47	0.898	-	-
	Q48	0.888	-	-
	Q49	0.914	-	-
	Q50	0.761	-	-
	Q51	0.733	-	-
	Q52	0.901	-	-
	Q53	0.922	-	-
	Q54	0.938	-	-
	Q55	0.934	-	-
	Q56	0.930	-	-
	Q57	0.932	-	-
Q58	0.945	-	-	
Cost management process	Q19	0.980	0.936	0.903
	Q20	0.929	-	-
	Q21	0.942	-	-
Risk management process	Q25	0.941	0.963	0.848
	Q26	0.903	-	-
	Q27	0.892	-	-
	Q28	0.949	-	-
	Q29	0.934	-	-
	Q30	0.963	-	-
	Q31	0.856	-	-
Quality management process	Q22	0.965	0.955	0.936
	Q23	0.997	-	-
	Q24	0.940	-	-
Procurement management process	Q32	0.942	0.939	0.840
	Q33	0.864	-	-
	Q34	0.914	-	-
	Q35	0.943	-	-
Communication management process	Q42	0.933	0.880	0.802
	Q43	0.937	-	-
	Q41	0.811	-	-

confirmed. All the coefficients for reliability and validity were greater than the specified cut-off points.

A CFA model with seven variables, namely communicative management processes, PMP, RMP, QMP, CMP, social competencies and communicative competencies was evaluated using model fit tests such as the Chi-square goodness of fit test, root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI) and standardised root mean square residual (SRMSR). The following were the evaluation criteria for each of these indicators: A non-significant Chi-square statistic indicated adequate model fit; RMSEA values less than 0.10 indicated adequate model fit, while values less than 0.08 indicated an excellent fit; CFI values greater than 0.90 indicated that model was not misspecified; TLI values greater than 0.95 imply a good model fit and finally, SRMSR values less than 0.08 indicate an adequate model fit, while values less than 0.05 imply an excellent model fit. Most of the indices indicated an adequate model fit for the CFA, except for the chi-square goodness of fit, which is rarely statistically non-significant because of its sensitivity to sample size ($\chi^2 = 2053.22$, $df = 968$, $P = 0.000$; $CFI = 0.999$; $TLI = 0.998$, $RMSEA = 0.071$; $SRMR = 0.046$).

Following the satisfactory results of the CFA, the data set was subjected to a path analysis of the hypothesis relationships. A collinearity analysis was performed before the test. Collinearity occurs when two or more predictor variables are closely related, which frequently leads to model overfitting. A variance inflation factor (VIF) value greater than 10 indicates that there is a problem with multicollinearity between variables in a study (Hair et al. 2019). Table 2 shows that the VIF for all variables was less than 10, indicating an acceptable level of collinearity between the variables.

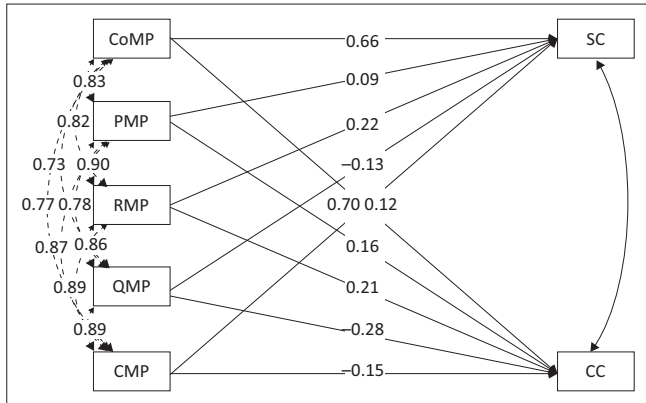
Figure 1, Table 3 and Table 4 show the results of the path analysis with standardised regression coefficients for the communication and social competency variables.

The coefficient of determination (R^2) was utilised to determine the fit of the hypothesised model. The coefficient of determination denotes the proportion of variance in an outcome variable that can be explained by a set of predictor factors. Table 3 shows that the five predictor variables explained 88.0% of the variance in communicative competencies and 87.9% of the variance in social competencies, indicating a high predictive effect on the

TABLE 2: Multi-collinearity test results.

Variable names	VIF
Cost management processes	8.17
Quality management processes	5.70
Risk management processes	8.40
Procurement management processes	7.08
Communication management processes	3.66

VIF, variance inflation factor.



CoMP, communicative management processes; PMP, procurement management processes; RMP, risk management processes; QMP, quality management processes; CMP, cost management processes; SC, social competencies; CC, communicative competencies.

FIGURE 1: Path regression estimates.

TABLE 3: Coefficient of determination (R^2).

Variable	R^2	Wald χ^2	Df	P
Communicative competencies	0.880	1629	5	< 0.001
Social competencies	0.879	1611	5	< 0.001

TABLE 4: Path coefficients.

Dependent variable	Predictor variable	Regression estimate	Standard error	β	Z	P
Communicative competencies	←CMP	0.1464	0.0664	0.1464	2.20	0.028
Communicative competencies	←QMP	-0.2758	0.0555	-0.2758	-4.97	< 0.001
Communicative competencies	←RMP	0.2060	0.0674	0.2060	3.06	0.002
Communicative competencies	←PMP	0.1590	0.0618	0.1590	2.57	0.010
Communicative competencies	←CoMP	0.7047	0.0445	0.7047	15.85	< 0.001
Social competencies	←CMP	0.1225	0.0668	0.1225	1.83	0.067
Social competencies	←QMP	-0.1292	0.0557	-0.1292	-2.32	0.020
Social competencies	←RMP	0.2247	0.0677	0.2247	3.32	< 0.001
Social competencies	←PMP	0.0893	0.0622	0.0893	1.44	0.151
Social competencies	←CoMP	0.6610	0.0447	0.6610	14.79	< 0.001

CoMP, communication management processes; PMP, procurement management processes; RMP, risk management processes; QMP, quality management processes; CMP, cost management processes.

dependent variable. Other fit indices (RMSEA = 0.046, CFI = 0.999, TLI = 0.998, and SRMR = 0.071) also indicated a satisfactory level of model fitness.

The CMP had a direct positive effect on communicative competencies ($\beta = 0.1464, P = 0.028$); the RMP had a direct positive effect on communicative competencies ($\beta = 0.206, P = 0.002$); the PMP had a positive effect on communicative competencies ($\beta = 0.159, P = 0.01$) and the communication management process had the largest positive effect on communicative competencies ($\beta = 0.7047, P = 0.001$). In contrast, the QMP variable had a statistically significant but negative impact on communicative competencies ($\beta = -0.2758, P = 0.001$).

Furthermore, CMP had positive but statistically insignificant effects on social competencies ($\beta = 0.1225, P = 0.067$), RMP had a positive direct effect on social competencies ($\beta = 0.2247, P = 0.001$), PMP had positive but not statistically significant

TABLE 5: Moderation analysis.

Independent variables	Dependent variables	Moderators/ interaction effects	Moderation effects	P
Project execution ->	Communicative competencies	Laptops	-2.2970	0.000
		Tablets	0.7448	0.000
	Social competencies	Laptops	-2.4006	0.000
		Tablets	0.8004	0.000

direct effects on social competencies ($\beta = 0.0893, P = 0.151$) and communication processes had the strongest positive effects on social competencies ($\beta = 0.661, P = 0.001$). The variable QMP, on the other hand, had a statistically significant but negative influence on the variable social competencies.

The Hayes (2017) Process tool was used to test the moderating effects. Mobile technologies (e.g. laptops, tablets, smartphones, PDAs and drones) are proposed as potential moderators of the relationships between project execution (an independent variable) and managerial competencies in the study (dependent variables). When the strength or direction of a relationship between two variables is affected by the level of a moderator, this is referred to as moderation. Any P less than 0.05 indicates a moderation effect, while any P greater than 0.05 indicates no moderation effect. Table 5 presents the results of the moderation analysis. Evidence suggests that device type (especially tablets) moderated the relationship between the use of MT during project execution and the development of communicative competencies. The results also show that device type (especially tablets) moderated the relationship between the use of MT during project execution and the development of social competencies.

Discussion

The study sought to investigate the extent to which the adoption of MTs during project execution impacts specific competencies of the PM team. The study also sought to address the extent to which the choice of a specific MT could moderate the relationship between MT use and the realisation of these competencies in selected ECFs. This topic is under-researched in emerging economies, especially in the South African context.

Consistent with previous research that demonstrates the capacity of communication skills to facilitate collaborative interaction that enhances and integrates support for cost, scope, time and quality aspects of projects (Al-Nady, Hawary & Alolayyan 2016; Sanchez, Terlizzi & De Moraes 2017; Zulch 2014), our findings demonstrate that the use of MTs during CMP, RMP, PMP, and communication management process was directly and positively linked to communicative competencies. However, these findings are inconsistent with previous research (Mohammadi, Sarvestani & Nouroozi 2020), as they reveal a statistically significant but negative impact of the use of MTs during the QMP on communicative competencies. This outcome is not surprising given the deterioration of quality measurement arising from

the use of MTs (Hilty et al. 2020). The deterioration in quality measurement as a result of the use of MTs can be attributed to the screen size (Wilmer, Sherman & Chein 2017) that complicates the visibility of project drawings, the limited functionality of some phones (Chu et al. 2021; Wilmer et al. 2017), and distractive tendencies of phones in work environments that can complicate the quality of project work.

Our results also demonstrate that the use of MTs during the RMP and communication management process was directly and positively linked to social competencies, with CoMP having the strongest positive effects. This confirms previous research showing the positive effects of job-related MT use (Park, Kim & Lee 2020). Although results indicate a positive link between the use of MTs for CMP and PMP and social competencies, this link is statistically insignificant. Such findings could be attributed to the possibility that even though ECFs are deploying mobiles for these two functions, such use was not extensive and intensive enough to exert a significant impact on the development of social competencies. One can argue that a high volume of ECF-mobile usage would have spurred the development of social competencies, but the research findings show that quantity does not equal quality (Mohammadi et al. 2020). Furthermore, our findings reveal a statistically significant but negative impact of the use of MTs for QMP on social competencies. This implies that the more ECFs use mobiles for quality promotion, the less their social competencies were positively impacted. These findings are somewhat inconsistent with previous studies linking the increased use of MTs to important work-related outcomes such as organisational citizenship behaviour even though the finding provides some support for previous studies that suggest that levels of MTs use may negatively influence the QMP (Lavy 2019).

The moderation results demonstrate that laptops and tablets moderate the relationship between the use of MTs during project execution and communicative competencies, as both of their P (0.000) are lower than 0.05. Furthermore, the results indicate that laptops and tablets also moderate the relationship between the use of MTs during project execution and social competencies, as both of their P (0.000) are lower than 0.05. A significant conclusion is that there are statistically significant relationships between the use of MTs during project execution and communicative competencies ($R^2 = 0.888$; $P < 0.001$). Also, statistically significant relationships were found for social competencies ($R^2 = 0.888$; $P < 0.001$).

Limitations, implications and recommendations

While the study sheds light on the impact of MT use during project execution on communicative and social competencies, it has some limitations. To address the hypotheses, the study employed a cross-sectional design. While Wang and Cheng (2020) acknowledge that a cross-sectional study is relatively inexpensive and simple to conduct, its major flaws are that it does not allow researchers to conduct follow-ups with

respondents over time to establish whether there are dynamic variations in the variables measured. As such, this failure to address changes in variables over an extended period makes causal inferences difficult. Having said that the rigour used in the data analysis, combined with the use of mainstream literature in the development of the scales, was beneficial in producing credible results.

Secondly, while several ECFs were discovered in other parts of the Free State province, the scope of this investigation was limited to CIDB registered ECFs in the province. The registered ECFs were chosen as they met most of the criteria of being registered companies, adhering to labour practises and being law-abiding firms (e.g. in terms of tax payment), allowing for the development of a homogeneous sample from which findings could be generalised. As a result, while the findings can be generalised to registered ECFs, they may not apply to unregistered ECFs because their characteristics may differ from those of registered ones. As a result, while the study can be applied to all registered ECFs in the Free State province, the findings may not apply to all ECFs as their characteristics may differ.

Despite the aforementioned limitations, the study presents some implications for owners and managers. The findings confirm that the use of MTs during project execution has a direct and positive impact on communicative and social competencies. This demonstrates that senior project managers need to strategically concentrate on those aspects of project execution where use of MTs would most enhance social and communicative competencies. For instance, senior project managers must advise project staff and their team to concentrate on risk management and communication management processes of project execution as these have the greatest chances of enhancing their social and communicative competencies.

Concerning the type of MTs that moderate the interaction between the use of MTs and social and communicative competencies, we established that tablets moderate this relationship. Therefore, senior project staff must not only create pertinent operational conditions under which this technology is employed during project execution to optimise its impact on social and communicative competencies but also emphasise its seamless integration into project execution to realise the intended impact on competency development.

As a result, the study concentrated solely on direct relationships between variables and the moderating effect of the type of MT as a moderator variable of the technology use-competency relationship. Therefore, future research can explore the extent to which factors such as owners' or managers' experience with technologies, ease of use, availability and perceived usefulness of such technologies could serve as moderators of the relationship between the use of MTs and the development of competencies of project

staff. Also, future research can explore the differentiation and appropriation of the types of MTs in other less technology-intensive industries such as retail and apparel industries.

Given the significant but negative impact of the use of MTs during the QMP on communicative competencies, the effective use of technology in ways that positively impact the quality of merchandise and enterprises (Wei, Feng & Zhang 2017) necessitates a complex strategy and analysis of technology development for the enhancement and growth of service provision (Amesho et al. 2021). Given the limitations of MT in improving the quality of PM, sufficient emphasis must be deployed at improving the interfaces and capabilities of MTs to improve (PM) process and practises within organisations (Amesho et al. 2021).

As screen size and distractive tendencies were provided as possible explanatory factors for the significant but negative relationships between MT use during quality management phases of project execution and communicative competencies, ECFs need to continually engage in intensive research and development to ensure continuous innovation and build on existing human capital in the production of new products and new methods of producing goods (Amesho et al. 2021; Subrahmanya 2005). Emerging construction firms may also partner with local municipalities, metropolitan cities and governments in the scoping and mapping of the existing state of technology and technology management for sustainable competitive advantage, for deploying this knowledge for better understanding of their needs in partnerships, and to make informed decisions to invest in research and development (R&D) and purchasing policies and practises (Tshabalala & Khoza 2019; Zhu & Lin 2019).

As the effective development of organisations (e.g. ECFs) and their survival cannot be insulated from their national and international environments (Feng et al. 2020), the effective management of technology and innovations by ECFs, PM associations, municipalities and governments could be critical to the enhancement of competencies and competitive advantage of such firms (Amesho et al. 2021).

In view of the evidence on the positive but insignificant nexus between the use of MTs for CMP and PMP and social competencies, this could point to the limited knowledge of ECF owners/managers of modern techniques and design tools for creating technological and innovation processes, including how they could be effectively deployed for PM and decision-making (Amesho et al. 2022). Given such a knowledge deficit, these entrepreneurs need further enlightenment on the reality that despite technological development constituting a procedure, the overhauling of innovation capacities (drawing on the affordances of modern technology) remains a ceaseless assignment for the organisation (Foss & Saebi 2018). The improvements on PM stages drawing on MTs would require a dynamic evolution of planning and research in improving capabilities or increasing utilities as well as improvements in technology,

products, processes, knowledge and experiences within organisational setting (Ferreira, Mueller & Papa 2020; Knudsen et al. 2021).

Given that tablets and laptops moderate the relationship between the use of MTs during project execution and communicative competencies, on the one hand, and the use of MTs during project execution and social competencies, on the other hand, the strategic planning, integration and accommodation of such technologies is key to the effective development of competencies. This is particularly important as organisations' technology invention and their ability to recognise, distribute and use information specifically are considered fundamental to meeting their customers' needs and enhancing their competitive advantage (Alavi & Leidner 2001; Hoosain, Paul & Ramakrishna 2020). Given that tablets were reported as moderating the technology use during project execution better than mobile phones, such differences must be factored into organisations' investments in technology and actualising information management ability to facilitate effective information management among individuals within an organisation (Amesho et al. 2021; Rodrigues & Fanco 2021).

Conclusion

This study explored the relationship between the use of MTs and the development of managerial competencies specifically communicative and social competencies. While the literature emphasised how MTs can be harnessed to support different PM activities of ECFs' owners/managers, this study provided empirical evidence that the use of MTs can improve managerial competencies during project execution. The study reports a strong and statistically significant relationship between the use of MTs during various project execution processes and managerial competencies (namely, communicative and social competencies). Based on the foregoing discussion, there is evidence to suggest that despite ECFs' owners/managers' ability to integrate MTs into their project activities, these managers must emphasise the type of MTs they harness during project execution to facilitate and enhance their managerial competencies.

Acknowledgements

The authors are grateful to the Central University of Technology (CUT) for funding the studies of the first author that made the write up of this article possible.

Competing interests

The authors have declared that no competing interest exists.

Authors' contributions

T.J.L. did the data collection and wrote the literature sections of this article. P.R. wrote the theory sections and the discussion and substantially reworked the different versions of the draft. He also supervised the Master's study on which this study was based. T.N. (the third author)

did the methodology section and also analysed the data for the article.

Ethical considerations

Ethical clearance to conduct this study was obtained from the Faculty Research and Innovation Committee of the Central University of Technology (no. FMSEC0318).

Funding information

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data availability

The SPSS data on which this article was based can be obtained from T.J.L. upon request. However, these data remain the intellectual property of CUT.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors, and the publisher.

References

- Al-Nady, B., Hawary, S. & Alolayyan, M., 2016, 'The role of time, communication, and cost management on project management success: An empirical study on sample of construction projects customers in Makkah City, Kingdom of Saudi Arabia', *International Journal of Services and Operations Management* 23(1), 76–112. <https://doi.org/10.1504/IJSOM.2016.073293>
- Alaloul, W.S., Liew, M.S. & Zawawi, N.A., 2016, 'Identification of coordination factors affecting building projects performance', *Alexandria Engineering Journal* 55(3), 2689–2698. <https://doi.org/10.1016/j.aej.2016.06.010>
- Alavi, M. & Leidner, D.E., 2001, 'Knowledge management and knowledge management systems: Conceptual foundations and research issues', *MIS Quarterly* 25(1), 107–136. <https://doi.org/10.2307/3250961>
- Amesho, K.T.T., Eduon, E.I., Naidoo, V. & Poee, S., 2021, 'Managing competitive advantage through technology and innovation systems and its impacts on service delivery within the Kaohsiung City Government in Taiwan', *South African Journal of Information Management* 23(1), a1348. <https://doi.org/10.4102/sajim.v23i1.1348>
- Amesho, K.T.T., Eduon, E.I., Naidoo, V. & Poee, S., 2022, 'Sustainable competitive advantage through technology and innovation systems in the local government authorities', *Africa's Public Service Delivery & Performance Review* 10(1), 19. <https://doi.org/10.4102/apsdpr.v10i1.573>
- Arditi, D., Gluch, P. & Holmdahl, M., 2013, 'Managerial competencies of female and male managers in the Swedish construction industry', *Construction Management and Economics* 31(9), 979–990. <https://doi.org/10.1080/01446193.2013.828845>
- Bajwa, A., 2022, 'Mobile and cloud technologies in the construction industry: What is the future of buildings?', *TechBullion*, viewed 04 October 2022, from <https://techbullion.com/mobile-and-cloud-technologies-in-the-construction-industry-permalink/>.
- Barney, J., 1991, 'Firm resources and sustained competitive advantage', *Journal of Management* 17(1), 99–120.
- Bedard, P., 2019, 'How mobile technologies are boosting construction site efficiency', *Area Development*, viewed 03 April 2019, from <http://www.areadevelopment.com/AssetManagement/April2013/construction-site-mobile-project-management-272725.shtml>.
- Bradberry, T. & Graves, J., 2005, *The emotional intelligence quick book: how to put your eq to work*, Simon & Schuster, New York.
- Carruthers, M.C., 2008, *Principles of management for quality projects*, CENGAGE Learning EMEA, London, UK.
- Chu, J., Qaisar, S., Shah, Z. & Jalil, A., 2021, 'Attention or distraction? The impact of mobile phone on users' psychological well-being', *Frontiers in Psychology* 12, 612127. <https://doi.org/10.3389/fpsyg.2021.612127>
- Correa, T., Pavez, I. & Contreras, J., 2018, 'Digital inclusion through mobile phones?: A comparison between mobile-only and computer users in internet access, skills and use', *Information, Communication and Society* 23(7), 1074–1091. <https://doi.org/10.1080/1369118x.2018.1555270>
- Dubois, D.D., 2002, 'What competencies and why are they important?', *Career Planning and Adult Development Journal*, 18(4), 1–7.
- Feng, B., Sun, K., Chen, M. & Gao, T., 2020, 'The impact of core technological capabilities of high-tech industry on sustainable competitive advantage', *Sustainability* 12(7), 2980. <https://doi.org/10.3390/su12072980>
- Ferreira, J., Mueller, J. & Papa, A., 2020, 'Strategic knowledge management: Theory, practice and future challenges', *Journal of Knowledge Management* 24(2), 121–126. <https://doi.org/10.1108/JKM-07-2018-0461>
- Fioravanti, M., Sena, B., Paschoal, L., Silva, L., Allian, A., Nakagawa, E. et al., 2018, 'Integrating project based learning and project management for software engineering teaching', in T. Barnes & D. Garcia (eds.), *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*, Baltimore, February 21–24, 2018, pp. 806–811.
- Foss, N.J. & Saebi, T., 2018, 'Business models and business model innovation: Between wicked and paradigmatic problems', *Long Range Planning* 51(1), 9–21. <https://doi.org/10.1016/j.lrp.2017.07.006>
- Goldie, J., 2016, 'Connectivism: A knowledge learning theory for the digital age?', *Medical Teacher* 38(10), 1064–1069. <https://doi.org/10.3109/0142159X.2016.1173661>
- Greve, H.R., 2020, 'The resource-based view and learning theory: Overlaps, differences, and a shared future', *Journal of Management* 47(7), 1720–1733. <https://doi.org/10.1177/0149206320967732>
- Grundmann, R., 2016, 'The problem of expertise in knowledge societies', *Minerva* 55(1), 25–48. <https://doi.org/10.1007/s11024-016-9308-7>
- Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E. & Tatham, R.L., 2019, 'Pearson new international edition', in J.F. Hair, W.C. Black, B.J. Babin, R.E. Anderson, & Tatham, R.L. (eds.), *Multivariate data analysis*, 8th edn., pp. 259–370, Pearson Education, Harlow.
- Hayes, A.F., 2017. *Introduction to mediation, moderation, and conditional process analysis: a regression-based approach*, Guilford Press, New York.
- Hendricks, G.P., 2019, 'Connectivism as a learning theory and its relation to open distance education', *Progressio: South African Journal for Open and Distance Learning Practice* 41(1), 1–13. <https://doi.org/10.25159/2663-5895/4773>
- Hilty, D., Chan, S., Torous, J., Luo, J. & Boland, R., 2020, 'A framework for competencies for the use of mobile technologies in psychiatry and medicine: Scoping review', *JMIR mHealth and uHealth* 8(2), e12229. <https://doi.org/10.2196/12229>
- Hoadley, G., 2019, *5 New technologies used in the construction industry in 2017*, Dg.ca, viewed 19 March 2019, from <http://www.dg.ca/blog/5-new-technologies-used-in-the-construction-industry-in-2017>.
- Holtmann, A., 2019, *4 Key benefits of mobile construction technologies and 12 ways they improve field functionality*, constructible.trimble.com, viewed 04 October 2022, from <https://constructible.trimble.com/construction-industry/4-key-benefits-of-mobile-construction-technologies-and-12-ways-they-improve-field-functionality>.
- Hoosain, M.S., Paul, B.S. & Ramakrishna, S., 2020, 'The impact of 4IR digital technologies and circular thinking on the United Nations sustainable development goals', *Sustainability* 12(23), 10143. <https://doi.org/10.3390/su122310143>
- Hynes, M. (eds.), 2021, *The smartphone: a weapon of mass distraction, The social, cultural and environmental costs of hyper-connectivity: sleeping through the revolution*, pp. 71–84, Emerald Publishing Limited, Bingley.
- Irfan, M., Khan, S.Z., Hassan, N., Hassan, M., Habib, M., Khan, S. et al., 2021, 'Role of project planning and project manager competencies on public sector project success', *Sustainability* 13(3), 1421. <https://doi.org/10.3390/su13031421>
- Kendrick, T., 2015. *Identifying and managing project risk: Essential tools for failure-proofing your project*, 3rd edn., AMACOM, New York, NY.
- Knudsen, E.S., Lien, L.B., Timmermans, B., Belik, I. & Pandey, S., 2021, 'Stability in turbulent times? The effect of digitalization on the sustainability of competitive advantage', *Journal of Business Research* 128, 360–369. <https://doi.org/10.1016/j.jbusres.2021.02.008>
- Larson, E.W. & Gray, C.F., 2017, *Project management: The managerial process*, 7th edn., McGraw-Hill Education, New York, NY.
- Lavy, S., 2019, 'Daily dynamics of teachers' organizational citizenship behavior: Social and emotional antecedents and outcomes', *Frontiers in Psychology* 10, 2863. <https://doi.org/10.3389/fpsyg.2019.02863>
- Light, J. & McNaughton, D., 2014, 'Communicative competence for individuals who require augmentative and alternative communication: A new definition for a new era of communication?', *Augmentative and Alternative Communication* 30(1), 1–18. <https://doi.org/10.3109/07434618.2014.885080>
- Makhalemele, P., 2016, 'The relationship between managerial competencies and performance of Internet cafés in the Free State region', Unpublished Master's dissertation, Central University of Technology, Bloemfontein.
- Martínez-Rojas, M., Marín, N. & Vila, M.A., 2016, 'The role of information technologies to address data handling in construction project management', *Journal of Computing in Civil Engineering* 30(4), 04015064. [https://doi.org/10.1061/\(asce\)cp.1943-5487.0000538](https://doi.org/10.1061/(asce)cp.1943-5487.0000538)
- McCroskey, J. & McCroskey, L., 1988, 'Self-report as an approach to measuring communication competence', *Communication Research Reports* 5(2), 108–113. <https://doi.org/10.1080/08824098809359810>
- Modern Contractor Solutions, 2019, *Mobile technology trends for heavy construction*, MCS mag, viewed 02 April 2019, from <https://mcsmag.com/mobile-technology-trends-for-heavy-construction/>.
- Mohammadi, M., Sarvestani, M.S. & Nouroozi, S., 2020, 'Mobile phone use in education and learning by faculty members of technical-engineering groups: Concurrent mixed methods design', *Frontiers in Education* 5, 16. <https://doi.org/10.3389/feduc.2020.00016>

- Morrison-Smith, S. & Ruiz, J., 2020, 'Challenges and barriers in virtual teams: A literature review', *SN Applied Sciences* 2, 1096. <https://doi.org/10.1007/s42452-020-2801-5>
- Müller, R., Drouin, N. & Sankaran, S., 2019, 'Modeling organizational project management', *Project Management Journal* 50(4), 499–513. <https://doi.org/10.1177/8756972819847876>
- Olanayan, R., 2019, 'Barriers to technology adoption among construction project managers in Nigeria', Unpublished Doctoral dissertation, Walden University, Minneapolis, MN.
- Parikh, J.H., Mody, E.J. & Pitroda, J.R., 2021, 'Effective project management using mobile application for construction projects: A review', *International Research Journal of Modernization in Engineering Technology and Science* 3(3), 1197–1203. https://www.academia.edu/45604792/EFFECTIVE_PROJECT_MANAGEMENT_USING_MOBILE_APPLICATION_FOR_CONSTRUCTION_PROJECTS_A_REVIEW
- Park, J.-C., Kim, S. & Lee, H., 2020, 'Effect of work-related smartphone use after work on job burnout: Moderating effect of social support and organizational politics', *Computers in Human Behavior* 105, 106194. <https://doi.org/10.1016/j.chb.2019.106194>
- Park, J., Kim, K. & Cho, Y., 2017, 'Framework of automated construction-safety monitoring using cloud-enabled BIM and BLE mobile tracking sensors', *Journal of Construction Engineering and Management* 143(2), 05016019. [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0001223](https://doi.org/10.1061/(ASCE)CO.1943-7862.0001223)
- Pm4dev.com, 2019, *Project quality management: Project management for development organizations*, viewed 03 April 2019, from <https://www.pm4dev.com/resources/free-e-books/5-project-quality-management/file.html>
- Popkova, E. & Zmiyak, K., 2019, 'Priorities of training of digital personnel for Industry 4.0: Social competencies vs technical competencies', *On the Horizon* 27(3/4), 138–144. <https://doi.org/10.1108/OTH-08-2019-0058>
- Project Management Institute (PMI), 2017, *A guide to the project management body of knowledge*, 6th edn., Project Management Institute, Newtown Square, PA.
- Rambe, P., 2018, 'Unravelling managerial competencies and the profitability of small technology-oriented businesses: A case of public access venues in an emerging economy', *South African Journal of Human Resource Management* 16(1), 1–15. <https://doi.org/10.4102/sajhrm.v16i0.1045>
- Rasiah, R., 2019, 'Building networks to harness innovation synergies: Towards an open systems approach to sustainable development', *Journal of Open Innovation: Technology, Market, and Complexity* 5(3), 70–90. <https://doi.org/10.3390/joitmc5030070>
- Redden, L., Collins, W. & Kim, J., 2017, 'Integration of construction mobile technologies into construction management curriculum: A case study', *Procedia Engineering* 196, 535–542. <https://doi.org/10.1016/j.proeng.2017.08.026>
- Ribeiro, A., Amaral, A. & Barros, T., 2021, 'Project manager competencies in the context of the Industry 4.0', *Procedia Computer Science* 181, 803–810. <https://doi.org/10.1016/j.procs.2021.01.233>
- Rodrigues, M. & Franco, M., 2021, 'Digital entrepreneurship in local government: Case study in Municipality of Fundão, Portugal', *Sustainable Cities and Society* 73, 103115. <https://doi.org/10.1016/j.scs.2021.103115>
- Sanchez, O., Terlizzi, M. & De Moraes, H., 2017, 'Cost and time project management success factors for information systems development projects', *International Journal of Project Management* 35(8), 1608–1626. <https://doi.org/10.1016/j.ijproman.2017.09.007>
- Sattineni, A. & Schmidt, T., 2015, 'Implementation of mobile devices on jobsites in the construction industry', *Procedia Engineering* 123, 488–495. <https://doi.org/10.1016/j.proeng.2015.10.100>
- Siemens, G., 2005, 'Connectivism: A learning theory for the digital age', *International Journal of Instructional Technology and Distance Learning* 2(1), 3–10. <http://www.itdl.org/>
- Siemens, G., 2017, *Connectivism, foundations of learning and instructional design technology*, viewed 22 October 2022, from <https://pressbooks.pub/lidtfoundations/chapter/connectivism-a-learning-theory-for-the-digital-age/>
- Subrahmanya, M.B., 2005, 'Pattern of technological innovations in small enterprises: A comparative perspective of Bangalore (India) and Northeast England (UK)', *Technovation* 25(3), 269–280. [https://doi.org/10.1016/S0166-4972\(03\)00094-4](https://doi.org/10.1016/S0166-4972(03)00094-4)
- Traxler, J., Barcena, E. & Laborda, J.G., 2015, 'Mobile technology for foreign language teaching: Building bridges between non-formal and formal scenarios', *Journal of Universal Computer Science* 21(10), 1234–1247.
- Tshabalala, M.M. & Khoza, L.T., 2019, 'Maximizing the organization's technology leverage through effective conflict risk management within agile teams', in C. De Villiers (ed.), *Proceedings of the South African Institute of Computer Scientists and Information Technologists*, Skukuza, September 17–18, 2019, pp. 1–6.
- Vial, G., 2019, 'Understanding digital transformation: A review and a research agenda', *The Journal of Strategic Information Systems* 28(2), 118–144. <https://doi.org/10.1016/j.jsis.2019.01.003>
- Wadei, S., 2019, *Effectively managing risks during project execution*, ProjectManagement.com, viewed 03 April 2019, from <https://www.projectmanagement.com/articles/421532/Effectively-Managing-Risks-During-Project-Execution>
- Wang, X. & Cheng, Z., 2020, 'Cross-sectional studies: Strengths, weaknesses, and recommendations', *Chest Journal* 158(1), 65–71. <https://doi.org/10.1016/j.chest.2020.03.012>
- Watt, A., Barron, M., Barron, A. & Wiley, D., 2014, *Project management*, 2nd edn., Open Textbook Library, Minneapolis, MN, viewed 28 January 2023, from <https://opentextbc.ca/projectmanagement/chapter/chapter-11-resource-planning-project-management/>
- Wei, F., Feng, N. & Zhang, K., 2017, 'Innovation capability and innovation talents: Evidence from China based on a quantile regression approach', *Sustainability* 9(7), 1218. <https://doi.org/10.3390/su9071218>
- Wilmer, H.H., Sherman, L.E. & Chein, J.M., 2017, 'Smartphones and cognition: A review of research exploring the links between mobile technology habits and cognitive functioning', *Frontiers in Psychology* 8, 605. <https://doi.org/10.3389/fpsyg.2017.00605>
- World Economic Forum, 2016, *WEF shaping the future of construction: A breakthrough in mindset and technology*, viewed 22 October 2022, from https://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report_.pdf
- Yanes, J., 2019, *Mobile technologies for third world development*, UNICEF Global Development Commons, viewed 04 October 2022, from <https://gdc.unicef.org/resource/mobile-technologies-third-world-development>
- Zhu, Z. & Lin, S.-F., 2019, 'Understanding entrepreneurial perceptions in the pursuit of emerging e-business opportunities: The dimensions and drivers', *Computers in Human Behavior* 95, 252–261. <https://doi.org/10.1016/j.chb.2018.02.015>
- Zulch, B., 2014, 'Communication: The foundation of project management', *Procedia Technology* 16, 1000–1009. <https://doi.org/10.1016/j.protcy.2014.10.054>