

## **A conceptual competencies-based framework to enhance the innovation capacity of Fourth Industrial Revolution entrepreneurs**

### **Abstract**

Entrepreneurship scholars have focused their research on compiling a list of competencies that enhance entrepreneurial behaviour. Yet, these efforts might be redundant as new competencies are necessary in the Fourth Industrial Revolution (4IR). Furthermore, previous research investigated entrepreneurial competencies (ECs) from a developed country perspective. This paper follows two phases in identifying ECs for the 4IR in a developing country context. During phase 1, a Delphi study is employed, whereby 12 participants provide 108 ECs (round 1) and 87 ECs (round 2) required for the 4IR. Based on an extensive literature review, a concept matrix is conducted in phase 2, in which 136 competencies are listed. After phase 2 has been conducted, 87 ECs are identified, of which 33 have resulted as the most cited in the literature. By utilizing this multi-dimensional holistic approach, we can distinguish the ECs necessary to increase entrepreneurs' capacity to innovate. The final analyses indicate 12 ECs, presented in a conceptual framework and categorized into four domains: cognitive (knowledge), functional (skills), social (attitudes and behaviours) and meta (facilitating learning). The findings illustrate the demand for specific ECs, although no additional ECs such as technology skills are identified for the 4IR within a developing country context.

**Keywords:** Delphi study, entrepreneurial competencies, Fourth Industrial Revolution, competency framework, innovation capacity, multi-dimensional holistic approach, developing country

## **Introduction**

Considering the drastic changes and contrast between the Fourth Industrial Revolution (4IR) and previous industrial revolutions, it is critical that innovative entrepreneurs excel in this revolution, and the best way forward is revisiting the system of Entrepreneurial Competencies (ECs) development (Abdullahi, bin Jabor and Akor, 2020:26:26). An educated workforce with the correct skills and the capacity for innovation is vital to the economy's competitiveness, robustness, productivity and sustainable growth (Herrington, Kew and Kew, 2018:28).

Scholars have identified critical thinking, problem-solving, self-management, working with people, management and communication of activities, technology use and development, core literacies and physical abilities as the most important skills for the 4IR (Brown, Hingel, Ratcheva and Zahidi, 2020:36). The 4IR is characterized by the so-called 'Cyber-Physical Systems', which are a consequence of the integration of production, sustainability and customer-satisfaction, forming the basis of intelligent network systems and processes (Bloem, Van Doorn, Duivesteyn, Excoffier, Maas and Van Ommeren, 2014:10).

As South Africa has an innovation impact with a value of only 2,8% with regard to the innovation levels of Total Entrepreneurial Activity (TEA) (Herrington, Kew and Kew, 2016:138) creativity, innovation, imagination and entrepreneurship are vital to sustaining and improving an advanced standard of living (Matthews and Brueggemann, 2015:23). Hence, we need to determine whether a developing country such as South Africa is aware of the ECs necessary for the 4IR workforce and job creators. In entrepreneurial literature, terms such as capabilities, resources, assets, competencies and skills are often used interchangeably (Colombo and Grilli, 2005:795). New skills, abilities and knowledge are seen as entrepreneurial competencies (EC), which include the relevant attitudes, values, beliefs, skills, abilities, personality, wisdom, expertise, mind-set and behavioural tendencies (Dixon, Meier, Brown and Custer, 2005:26; Moolman, 2017). Entrepreneurs require certain ECs, such as innovation, creativity, integration of business and technology skills, leadership and communication, as well as networking and sales, that allow them to respond to and navigate the layers of I4.0 technologies, and that enable new possibilities to arise in this globally connected and technology-fuelled world (Kruger and Steyn, 2021).

Rasmussen, Mosey and Wright (2011) argue that there is a gap in the literature relating to which ECs are necessary, how they are developed, and who provides them. In particular, this relates to ECs and their relationship to performance and business success (Mitchelmore and

Rowley, 2010:92). Several authors (Glancey, 1998; Van Vuuren and Nieman, 1999; Wickham, 2001; Erikson, 2002; Man, Lau and Chan, 2002; Ucbasaran, Westhead and Wright, 2002; Darroch and Clover, 2005; Perks and Strüwig, 2005; Westhead, Ucbasaran and Wright, 2005; Mamabolo, Kerrin and Kele, 2017; Moolman, 2017; Veliu and Manxhari, 2017) have investigated and identified the integrated model of entrepreneurial performance, which shows that the absence of any one skill will lead to zero performance. The person-entrepreneurial fit theory serves as a theoretical anchor in terms of which ECs will be instrumental in an entrepreneur's innovation capacity (IC) (Markman and Baron, 2003:281). This paper follows a qualitative two-phase data collection approach by means of a Delphi study and extensive literature review (concept matrix) to answer the research questions. Primary data were collected by means of a Delphi study, and secondary data were collected by compiling a Concept Matrix from the analysis of 24 articles.

The following research questions guide the study:

- i. Which specific ECs are significant for innovation within the 4IR in a developing country context such as South Africa?
- ii. How are these ECs categorized in order to distinguish the mechanisms through which knowledge, skills and competence are required and recognized?

In this paper we follow a multi-dimensional holistic approach in developing an entrepreneurial competency framework for the 4IR focusing on the individual entrepreneur. Furthermore, is the "Great Eight" competencies' embedded in the Universal Competency Framework (UCF) based on an individualistic perspective and used in this paper as a generic foundation for competency modelling (Bartram, 2011). From an individualistic perspective, ECs are created individually (Bird, 2002; Man et al., 2002). Conceptually the development of ECs is portrayed as individual ability and effort, which in turn is linked to venture formation and performance (Chandler and Lyon, 2009). This approach describes ECs as the collection of individual ECs required to achieve desired results (Straka, 2004:287), illustrating a unified typology of competence, knowledge and skills necessary for an occupational choice (Winterton, Delamare-Le Deist and Stringfellow, 2006:40) such as that of an entrepreneur. Furthermore, we use this approach (Le Deist and Winterton, 2005) to categorize the ECs (Cheetham and Chivers, 1996) into four categories: cognitive entrepreneurial competencies (CECs); functional entrepreneurial competencies (FECs); social entrepreneurial competencies (SECs); and meta entrepreneurial competencies (MECs). The main purpose of categorizing the ECs is to illustrate

the demand for specific ECs that will drive the shift to job creation within the 4IR, requiring competent entrepreneurs and increasing their level of capacity to innovate.

By answering the research questions, the study's contribution lies in the importance of the categories for entrepreneurship training and development. With a focus on educators in higher education and entrepreneurial institutions, such as entrepreneurship centres and incubators, ECs create awareness of the potential causal connection there might be between an entrepreneur's business success and innovative performance. This paper also sheds light on the development of the person-entrepreneurship-fit theory in terms of individual ECs linked to IC. Practically, this paper proposes a conceptual competencies-based framework for enhancing the IC of entrepreneurs in terms of the 4IR, which is able to distinguish the mechanisms through which knowledge, skills and competence are required and recognized. Lastly, due to fast-growing and changing digital technologies, comprehending the ECs necessary for an increased level of IC enables South African entrepreneurs to effectively prepare for this industrial revolution.

## **Theoretical foundation**

### *ECs in a developing country context*

Previous research has addressed the impact of future performance, that is, performance differences that are predicted by the differences in ECs (Levenson, 2005:5:5; Tisch, Abele and Metternich, 2019; Kruger and Steyn, 2021:1). From an emerging economies' perspective, the findings suggest that enforcing ECs has a significant effect on firm performance (Ahmad, Suseno, Seet, Susomrith and Rashid, 2018:5:5). For example, some managerial competencies were found to be associated with the performance of SMEs (Veliu and Manxhari, 2017:59).

Empirical evidence, in particular, suggests that in order to respond and navigate the layers of the 4IR technologies and enable new possibilities, entrepreneurs require certain ECs in this globally connected and technology-fuelled world (Kruger and Steyn, 2020:1). However, empirical research indicating which ECs are necessary for the 4IR in a developing country context is scarce.

### *EC development: individual versus organizational level*

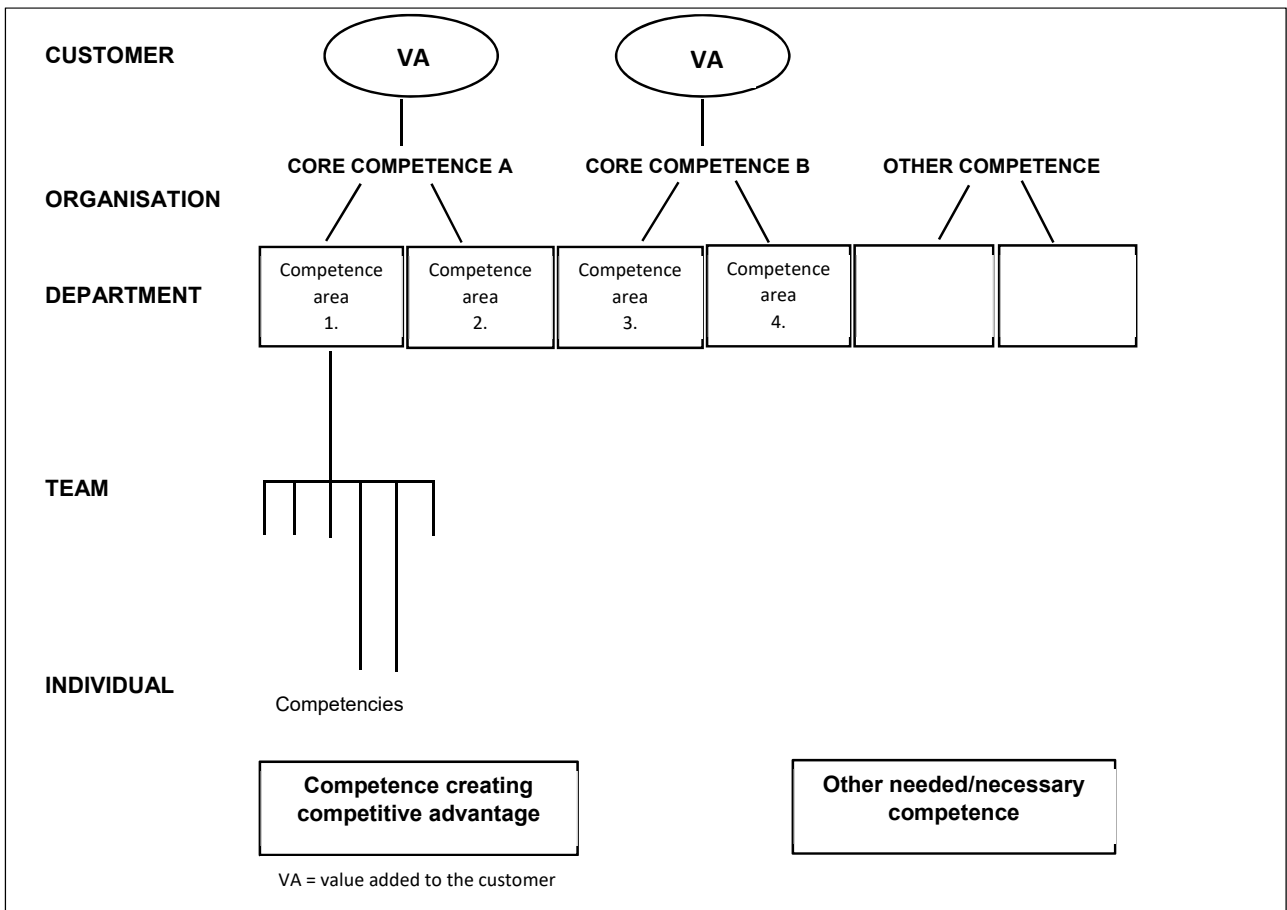
ECs are centred around the individual and viewed as independent of the social and task-specific context in which performance occurs, whereas skills level is a characteristic not only of a person, but of a context. Figure 1 presents the architecture of individual versus organizational competence. Organizational competence is made up of core competence, which is an ability to perform well in a certain job, and other competencies. Core competence is generally a concept that is used only on an organizational level and is made up of accumulated competences that an organization can exploit in its present or future to give added value to the customer (Miller and Morris, 2008). The complexity of tasks required by entrepreneurs dictates that they need to prepare themselves with relevant ECs that could be utilized in developing a successful venture (Ahmad, Halim and Zainal, 2010:73). For the purpose of this paper, the emphasis is on identifying ECs on an individual level that could contribute to the overall core ECs of an organization.

### *ECs and innovation capacity (IC) within 4IR*

Several developments have since occurred that have opened up the conversation on the importance of ECs significant for the 4IR (Prifti *et al.*, 2017; Abdullahi *et al.*, 2020; Kruger and Steyn, 2021). The literature provides emerging evidence of a positive relationship between ECs and innovative outputs, where empirical evidence suggests that entrepreneurs must have the right ECs to undertake innovative projects (Arafeh, 2016; Lilleväli and Täks, 2017; Fernando, 2020; Tittel and Terzidis, 2020; Kruger and Steyn, 2021) and key ECs for I4.0 (Grzybowska and Łupicka, 2017; Prifti *et al.*, 2017; Chaka, 2020; Lose and Kapondoro, 2020; Ramli, Rasul and Affandi, 2020; Plawgo and Ertman, 2021).

The person-entrepreneurship fit theory suggests that the higher the levels entrepreneurs have of distinct individual-difference dimensions, such as self-efficacy, ability to recognize opportunities, personal perseverance, superior social skills, and human and social capital, the closer the person-entrepreneurship fit will be. Empirical evidence derived from this theory suggests that the closer the match between individuals' attitudes, values, knowledge, skills, abilities and personality, the better their job satisfaction and their performance as entrepreneur will be (Markman and Baron, 2003:281). The theory further suggests that the closer the match

**Figure 1.** The competence architecture of an organization



Source: Adapted from Miller and Morris (2008)

between entrepreneurs' personal demographics and the requirements of being an entrepreneur (e.g., creating new ventures by transforming discoveries into marketable products), the more successful they will be (Markman and Baron, 2003). While it is true that entrepreneurs with highly developed ECs are more likely to introduce innovation to their businesses (Mitchelmore and Rowley, 2010), it is postulated that some of the ECs have more influence than others on innovative outcomes among entrepreneurs. Table 1 below indicates the following ECs that are linked to IC: creativity, innovation, critical thinking, self-management, opportunity recognition, networking, communication, leadership and problem-solving. Interestingly, these mentioned ECs have also been identified as ECs to enhance entrepreneurial behaviour. From this review, there seems to be no additional ECs that are specifically mentioned to enhance IC except for emphases placed on technology use and development (Brown et al., 2020) and the integration of business and technological skills (Kruger and Steyn, 2021) as important 4IR ECs.

### *Categorizing ECs*

Various scholars used different approaches and categories to categorize ECs. For example, Bonesso, Gerli, Pizzi and Cortellazzo (2018) used emotional, social and cognitive categories; Tittel and Terzidis (2020) used domain, personal and relationship competence, while Chandler and Jansen (1992) used five competency domains that include: managerial competence (human and conceptual), ability to recognize opportunity, drive to see the venture through to fruition, technical-functional competence and political competence. In a developing country context, the study by (Botha, Van Vuuren and Kunene, 2015a:59) focused on the importance of the proficiency in ECs for start-ups and established SMEs, and they identified and clustered functional and enterprising competencies. Certain professional competence models are similar, such as that of Cheetham and Chivers (1996:20), which includes MECs, CECs, FECs, personal and behavioural competence, as well as ethical competence. Similar to that of Cheetham and Chivers (1996) and Le Deist and Winterton (2005:40), and also as used in the Bharwani and Talib (2017) study, Winterton *et al.* (2006) developed a holistic model of competence and a unified typology of knowledge, skills and capabilities, including MECs, CECs, FECs and SECs.

**Table 1.** Literature review: EC linked to innovation capacity

ECs	References
<p>Problem-solving, financial management, critical thinking, emotional intelligence, research/information retrieval, creativity/innovation, team working, communication, active learning, reasoning, organization, interpersonal organization, leadership, self-directed thinking, life-long learning, time management, resource management, public presentation, critical evaluation of literature, respect for colleagues' views, integrated business and technology skills.</p>	<p>(Abdullahi <i>et al.</i>, 2020:27; Kruger &amp; Steyn, 2021:9).</p>
<p>Strategic competency, conceptual competency, opportunity competency, relationship competency, technical competency and innovative performance to undertake innovative projects.</p>	<p>(Mohsin <i>et al.</i>, 2017:93,96)</p>
<p>Opportunity-seeking and initiatives, persistence, fulfilling commitments, demand for quality and efficiency, taking calculated risks, goal-seeking, information-seeking, systematic planning and monitoring, persuasion and networking, independence and self-confidence.</p>	<p>(Arafeh, 2016)</p>
<p>Innovation, creativity, integrated business and technology skills, leadership and communication, networking and sales.</p>	<p>(Kruger &amp; Steyn, 2021)</p>
<p>Opportunity recognition, creativity, vision, valuing ideas, ethical and sustainable thinking.</p>	<p>(Stenholm, Ramström, Franzen &amp; Nieminen, 2021)</p>
<p>Creativity, entrepreneurial thinking, problem-solving, conflict-solving, decision-making, analytical skills, research skills, efficiency orientation.</p>	<p>(Grzybowska &amp; Łupicka, 2017)</p>
<p>Social skills, cognitive skills, personal/mental abilities, process skills, system skills, technical skills, content skills, intercultural skills and resource management skills.</p>	<p>(Eberhard, Podio, Alonso, Radovica, Avotina, Peiseniece, Caamaño Sendon, Gonzales Lozano &amp; Solé-Pla, 2017).</p>

Source: Own compilation



The four major categories identified for 21st century knowledge, skills and abilities (KSAs) are: information media and technology literacy, inventive thinking, communication and collaboration, productivity and results (Boyles, 2012). Boyles (2012) further split these ECs into cognitive, social and action-oriented categories in formulating a model for undergraduate entrepreneurship education. Annexure 1 provides a summary of previous work on ECs which categorized competencies into cognitive, meta, functional and social categories. This paper adopts the multi-dimensional holistic approach that is followed by various scholars (Cheetham and Chivers, 1996; Le Deist and Winterton, 2005; Winterton *et al.*, 2006; Bharwani and Talib, 2017; Moolman, 2017) where ECs are clustered into these four categories, as discussed next.

### *The multi-dimensional holistic approach to categorizing ECs*

Moolman (2017:39) argued for a holistic conception of competence, as it incorporates both the behavioural and functional approaches to competence and competency. Le Deist and Winterton (2005) adapted Cheetham and Chivers (1996) model by blending the personal and occupational competences and created a four-dimensional view on competence. Based on the research into competence domains (as illustrated in Annexure 1), each of the four categories were supported by the following scholars: CECs (Cheetham and Chivers, 1996; Le Deist and Winterton, 2005; Winterton *et al.*, 2006; Nassif, Ghobril and Silva, 2010; Boyles, 2012), FECs (Cheetham and Chivers, 1996; Le Deist and Winterton, 2005; Winterton *et al.*, 2006; Botha *et al.*, 2015a), SECs (Cheetham and Chivers, 1996; Winterton *et al.*, 2006; Boyles, 2012; Erol, Jäger, Hold, Ott and Sihm, 2016) and MECs (Cheetham and Chivers, 1996; Le Deist and Winterton, 2005; Winterton *et al.*, 2006).

These four competence categories were used to categorize the final list of ECs identified in this study as follows:

- CECs: underpinning theory and concepts as well as informal tacit knowledge gained experientially; knowledge, the “know what” that is underpinned by understanding the “know why”
- FECs: skills or know-how and things that a person should be able to do and to demonstrate
- SECs: behavioural competencies or knowing how to behave; some behaviours and attitudes related to entrepreneurial competence are, for example, having a positive attitude towards change and showing initiative

- MECs: a comprehensive concept of the multidimensional construction of competence; it further refers to the element that facilitates the acquisition of other competencies

### *The four competence categories and IC*

Opportunity recognition, decision making, proactiveness, resilience, creative problem-solving and imaginativeness and innovation/innovating are categorized as cognitive competencies in this study as they all are based on the possession of appropriate work-related knowledge, skills (Omimi and Zeng, 2018:4) and the ability to put them to effective use (Cheetham and Chivers, 1996:24). In linking cognitive competencies and IC, ECs such as systems thinking, pattern recognition, opportunity recognition (Sánchez, 2012:175; Bonesso *et al.*, 2018:224) play a key role. A positive attitude, networking and leadership are categorized as social competencies as they all comprise attitudes and behaviours in work-related situations (Cheetham and Chivers, 1996:24). Ameen, Hameed, Bashir, Bashir and Amin (2015:189) argue that when entrepreneurs employ strategic management actions such as innovation, social capital, networking, and organizational learning combined with interpersonal skills, then they will gain competitive advantage. Value creation is categorized as a functional competency, as it is based on the ability to perform a range of work-based tasks effectively to produce specific outcomes (Cheetham and Chivers, 1996:24). Schneider (2017:252) suggests that ECs can be operationalized by functional tasks related to managerial skills, self-efficacy, orientations of competition, risk-taking and innovation, and the founder and innovator identity. Problem-solving and cognitive ability are categorized as meta competencies, as they facilitate learning (Cheetham and Chivers, 1996:22) and the ability to put the focus on the “know-how” and combine and relate a set of innovative skills in different situations (Arisó, Giroto and Fernandez, 2016:51).

### **Methods used in identifying the relevant ECs**

In this paper a two-stage methodological approach is followed to: 1) answer the research questions and 2) develop the conceptual framework. Figure 2 explains the methodological principles that were integrated in these two phases. Phase 1 is undertaken to identify ECs required of entrepreneurs for the 4IR, through a Delphi study. In phase 1, the Delphi method facilitated the structured communication of participants (in this case, academics, industry experts and entrepreneurs), often geographically dispersed, for the purpose of gathering knowledge or arriving at a consensus on a topic (Holmes and Scaffa, 2009:82). Using the

Delphi method provides a less hierarchical and more ethical approach to conducting research that is built upon the principles of reciprocity, relationship building, and translational learning between communities and professional researchers (Brady, 2015:2). This research strategy was used in the Delphi study, and an inductive approach was applied where qualitative data were collected and theory developed as a result of the data analysis (Saunders, Lewis and Thornhill, 2016:145). Using a cross-sectional design, taking the research questions into consideration, enabled us to study multiple actions which did not differentiate between cause and effects or the sequences of events. The primary data from the Delphi study were collected over a period of three months.

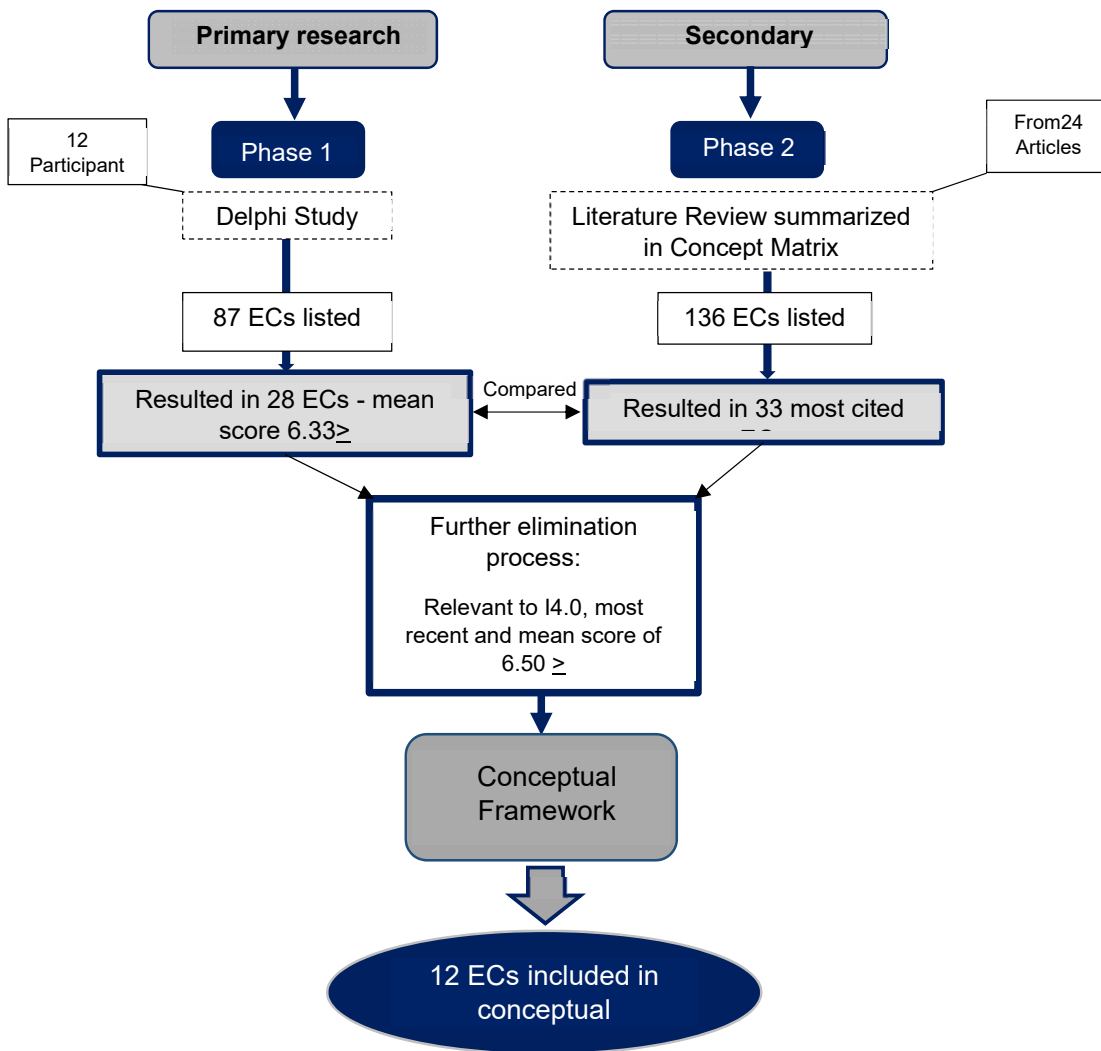
Phase 2 includes an extensive literature review which is summarized in a concept matrix. The concept matrix enabled us to conduct a critical comparative literature review (Klopper, Lubbe and Rugbeer, 2007:62) to incorporate all the possible ECs for the conceptual framework. This method is chosen to ensure that all the required ECs were included that had been considered based on the Delphi results, as well as those ECs identified and tested in previous research studies, which could not simply be ignored.

### **Sample: Delphi study**

For the Delphi study, the targeted panel size was between 10 and 25 industry experts, academics and entrepreneurs. Although no single sampling frame exists, the following sources were used as the sampling frame:

- Academics situated at 11 different institutions (University of Cincinnati, University of Pretoria, University of Cape Town, University of South Africa, University of Stellenbosch, University of Johannesburg, Nelson Mandela University, University of the Free State, Wits University, North West University and Warrington College of Business) that have a minimum of an Honours degree. These academics ranged from lecturers to professors with a specialty in the field of entrepreneurship.

**Figure 2.** Phased approach towards development of the conceptual framework



Source: Own compilation

- Entrepreneurs who had at least five years' experience as an entrepreneur, and who themselves were innovators in their respective fields such as automation, strategic innovation and corporate venturing and data analytics.
- Industry experts who had experience in working with innovative entrepreneurs or who had specialized in the field of entrepreneurship or 4IR.

Thirty-eight experts were initially identified through using purposive sampling to participate in the Delphi study; of these eighteen agreed to participate. It was anticipated that some participants would drop out of the exercise over time, and thus a final sample of 10–18 individuals was desired, as recommended by Okoli and Pawlowski (2004). To that end (summarized in Figure 2), a total of 12 final panellists completed both rounds 1 and 2, consisting of seven academics, two entrepreneurs, two industry experts and one academic-entrepreneur. These panellists had between 9 and 26 years of work experience, with their field of expertise mainly in entrepreneurship. Four participants were professors, one an associate professor, three had doctoral degrees, three had masters degrees and one a honours degree. Table 2 provides a summary of the biographical information of the Delphi panellists.

## **Data collection**

### *Delphi method*

In **round 1**, panel members were sent an initial survey via email asking them to generate a complete list of ECs they believed to be required for the 4IR – they were not limited to an amount, but were requested to identify no fewer than 10 ECs. They were provided a column to list the identified ECs and another column in which to provide a definition or description of the competency. The respondents were then asked to use the identified ECs and classify them under one of the four categories (domains): CECs, FECs, SECs or MECs. The description of each category was given to the participants before answering the question.

The results from round 1 were used to generate a total list of 108 items. The compilation included some items that appeared to be similar and were combined as one (such as ability to learn continuously and life-long learning; and conveying a compelling vision and visualization), this resulted in 87 items (presented in Figure 2). Table 3 provides a summary of

**Table 2.** Summary of Delphi panellists

	<b>Job title</b>	<b>Field of expertise</b>	<b>Years of experience</b>	<b>Country of residence</b>
<b>Panellist 1</b>	Senior Lecturer	Small business and entrepreneurship policies	12	Republic of South Africa
<b>Panellist 2</b>	Project Specialist: Business Incubation	Business development and Incubation	9	Republic of South Africa
<b>Panellist 3</b>	Business owner	Entrepreneur: Own psychological practice	26	Republic of South Africa
<b>Panellist 4</b>	Professor	Family Business Entrepreneurship	20	Republic of South Africa
<b>Panellist 5</b>	Lecturer	Business owner of multiple small businesses	15	Republic of South Africa
<b>Panellist 6</b>	Head of Department	Innovation specialist	20	Republic of South Africa
<b>Panellist 7</b>	Lecturer/Professor	Entrepreneurial orientation, intention, start-up, business plans etc.	25	Republic of South Africa
<b>Panellist 8</b>	Lecturer/Researcher	Lecture & research	20	Republic of South Africa
<b>Panellist 9</b>	Director	PhD	25	Republic of South Africa
<b>Panellist 10</b>	Professor	Entrepreneurship	36	USA
<b>Panellist 11</b>	Professor	Training & development, Behaviour, Corporate Entrepreneurship, Corporate Venturing	25	Republic of South Africa
<b>Panellist 12</b>	CEO	Business Incubation	10	Republic of South Africa

Source: Own compilation

the ECs and four categories, as identified by the Delphi panellists as well as the literature review. The definitions of the ECs are provided based on the choices of the majority of the Delphi panellists and scholars in the literature review. The definitions are therefore compared with how the ECs are defined in the literature in order to get a clear conceptual definition of each EC and to be able to categorize them into the four categories. None of the Delphi panellists provided definitions for decision-making and positive attitude. Creativity and innovation seemed to be used interchangeably when the panellists defined innovation/innovating. As there were some inconsistencies between the categorization of the ECs from the Delphi panellists and the literature review; some ECS were categorized into more than one category (as illustrated in Table 3). For example, the majority of the Delphi panellists categorized decision-making as an FEC and the literature categorized it as a CEC; therefore it is categorized in the conceptual framework (presented later in the paper) as both a FEC and CEC. Proactiveness was categorized by the Delphi panellists as CEC and FEC, with no support from literature. Problem-solving, for example, was identified as an MEC by the Delphi panellists and categorized as an MEC, CEC and SEC in the literature review. In this case, the researcher referred back to the main definitions of the four categories as defined by Le Deist and Winterton (2005) and categorized problem-solving as an MEC and CEC.

In **round 2**, the Delphi study was conducted through an email, containing an online survey link that was sent to the participants, which included a list of 87 ECs (refer to Figure 2) and the definitions or meanings that had resulted from round 1. The participants were asked to rate their level of agreement for each EC on a 7-point Likert scale ranging from 1 = Strongly Disagree, 2 = Disagree, 3 = Slightly Disagree, 4 = Neutral, 5 = Slightly Agree, 6 = Agree and 7 = Strongly Agree.

The data from round 2 were analysed to determine the mean score of the items. The top 48 ECs had a mean score of 6.00 and above, and 28 ECs had a mean score of 6.33 and above. There were five ECs that had a mean score of 6.67 (refer to Figure 2). Spearman correlation coefficients were conducted on the 48 ECs that had mean scores above 6.00. This was done to determine strong correlations (above 0.8) between the ECS. The ECs that were similar according to their definitions were eliminated. If the correlation was very strong and above 0.8,

**Table 3.** Definitions and categorization as identified by the Delphi panellists and literature review scholars

ECs	EC Definitions as defined by the majority of the Delphi panellists	EC Definitions as defined by the majority of the literature review scholars (Annexure 2 – Conceptual definitions)	Four categories as categorized by the majority of the Delphi panellists	Four categories as categorized by the majority of the literature review scholars (Annexure 2)
<b>Decision-making capability (FEC and CEC)</b>	No definition given	Considering the relative costs and benefits of potential actions to choose the most appropriate one (Gray, 2016).	FEC	CEC (Bharwani & Talib, 2017)
<b>Proactiveness (CEC and FEC)</b>	<ol style="list-style-type: none"> <li>1. Tendency to initiate and maintain actions that directly alter the surrounding context.</li> <li>2. Visualize opportunities and act.</li> </ol>	Proactive behaviour involves acting in advance of a future situation, rather than just reacting. It means taking control and making things happen rather than just adjusting to a situation or waiting for something to happen. (No formal definition found in a journal)	CEC/FEC	
<b>Leadership skills (FEC and SEC)</b>	To be able to lead a workforce already skilled.	Minimizes politics in the workplace; Expects excellence from all employees; Demonstrates good people skills; Shares information with employee; Is a good coach or mentor (Dixon et al., 2005).	FEC	SEC (Amini et al., 2018) (do Carmo et al., 2019)
<b>Networking ability (SEC)</b>	<ol style="list-style-type: none"> <li>1. The skill to connect with micro, meso and macro relevance. Nationally and internationally.</li> <li>2. Having a broad group of peers that are all switched on to developments</li> </ol>	Using deliberate strategies to influence or persuade others; uses key people as agents to accomplish objectives; acts to develop and maintain business contracts (Santandreu-Mascarell et al., 2013).	SEC	SEC (Bharwani & Talib, 2017) (Amini et al., 2018)  FEC (Botha et al., 2015)
<b>Cognitive ability (MEC)</b>	It indicates the ability to switch between different types of	The ability to generate or use different sets of	MEC	



	thinking dimensions and mindsets.	rules for combining or grouping things in different ways (Gray, 2016).		
<b>Problem-solving (MEC and CEC)</b>	<ol style="list-style-type: none"> <li>1. This indicates a creative mindset to make effective judgement calls to aid in robust data-driven decision making.</li> <li>2. Identify new and potentially unique ideas to achieve goals.</li> </ol>	Demonstrates good analysis skills; Has the ability to prioritize problems; Has good critical thinking skills; A problem solver (Dixon et al., 2005).	MEC	<p>MEC (Bharwani &amp; Talib, 2017)</p> <p>CEC (Complex problem-solving) (Boyles, 2012)</p> <p>SEC (Boyles, 2012)</p>
<b>Creative problem-solving and imaginativeness (CEC)</b>	The ability to relate previously unrelated objects or variables to produce novel and appropriate or useful outcomes.	The ability to relate previously unrelated variables or objects to produce novel and appropriate or useful outcomes (Morris et al., 2013).	CEC	<p>CEC (Lateral thinking/creative problem-solving) (Bonesso et al., 2018)</p>
<b>Innovation/Innovating (MEC and CEC)</b>	<p>Creativity and innovation: The ability to become more creative in ways of thinking and doing in a changing environment.</p> <p>Innovation management, explore and experiment with innovative approaches. Combine knowledge and resources to achieve goals. Able to apply innovation concepts to achieve real results.</p> <p>Creativity:</p> <ul style="list-style-type: none"> <li>• Trait that enables and catalyses newness, problem solving and a key ingredient of innovation.</li> <li>• Develop ideas and opportunities to create value, including better solutions to existing and new challenges</li> </ul>	<p>Innovating: making changes in something established, especially by introducing new methods, ideas, or products.</p> <p>Innovation: Introduction, establishment, institution, commencement, novelty, departure from the old, introduction of new and improved methods and things, modernization, drastic change, breaking of a precedent (Antonites, 2017).</p>	MEC	<p>MEC (Creativity) (Cheetham &amp; Chivers, 1996)</p> <p>CEC (Creativity and innovation) (Bharwani &amp; Talib, 2017) (Boyles, 2012)</p> <p>SEC Innovation (Boyles, 2012)</p>
<b>Value creation (FEC)</b>	Capabilities of developing new	Capabilities of developing new	FEC	

	products, services, and/or business models that generate revenues exceeding their costs and produce sufficient user benefits to bring about a fair return.	products, services, and/or business models that generate revenues exceeding their costs and produce sufficient user benefits to have a fair return (Morris et al., 2013).		
<b>Resilience (MEC and CEC)</b>	<ol style="list-style-type: none"> <li>1. The ability to rapidly adapt to turbulent changes in the market and macro environment.</li> <li>2. Ability to cope with stresses and disturbances such that one remains well, recovers, or even thrives in the face of adversity.</li> </ol>	The ability to cope with disturbances and stresses in such a way that one remains well, recovers, or even thrives in the face of adversity (Morris et al., 2013).	MEC/CEC	
<b>Positive attitude (FEC)</b>	No definition given	An attitude is defined as "a mental position with regard to a fact or state; a feeling or emotion toward a fact or state." The dictionary goes on to state that the word "positive" can be used as "having a good effect; favourable; marked by optimism." (No formal definition found in a journal)	FEC	
<b>Opportunity recognition (FEC and CEC)</b>	<ol style="list-style-type: none"> <li>1. Being able to identify a solution to a problem</li> <li>2. Recognizing and developing market opportunities</li> <li>3. The capacity to perceive changed conditions or overlooked possibilities in the environment that represent potential sources of profit or return to a venture.</li> </ol>	The capacity to perceive changed conditions or overlooked possibilities in the environment that represent potential profit or return to a venture (Morris et al., 2013).	FEC	CEC (Boyles, 2012)

but the definitions were distinct, the ECs were included. This process resulted in 28 ECs, illustrated in Table 3.

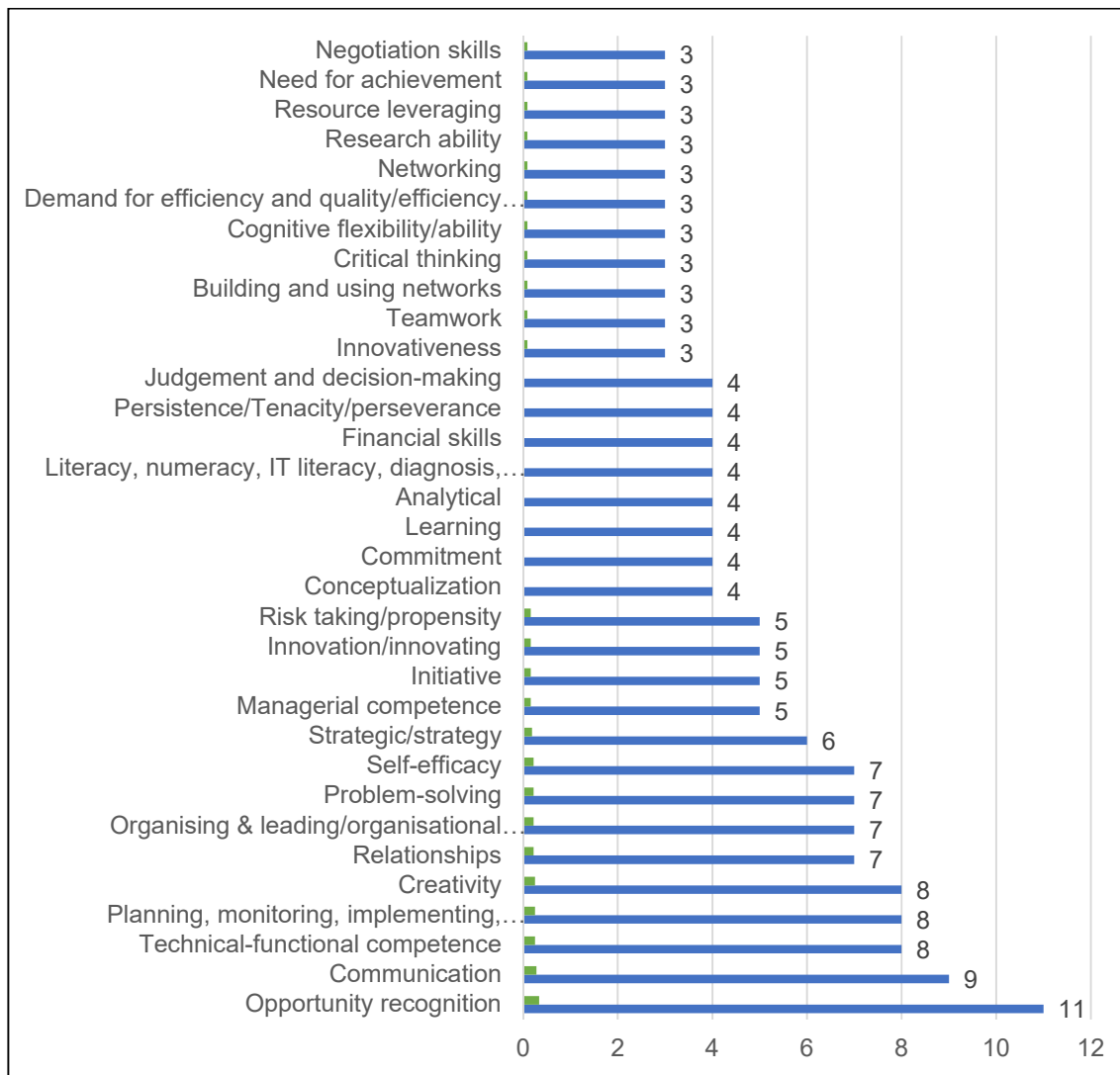
### *Concept Matrix*

To identify ECs significant for innovation and relevant for the 4IR, a systematic literature review was conducted, which offered a rigorous view of research results (Vom Brocke, Simons, Niehaves, Riemer, Plattfaut and Cleven, 2009:2208). Following the guidelines of Webster and Watson (2002), a search was conducted using the following keywords: ECs, 4IR skills, 4IR entrepreneurial skills, 4IR and abilities, key ECs for I4.0, 4IR and education, education for innovation and 21st century ECs. Finally, 24 resources including seventeen journal articles, three books, two web pages, one conference paper and one review that proposed ECs for I4.0 were considered and analysed (presented in Annexure 3). The mentioned ECs were extracted from each article and a concept matrix was built (Webster and Watson, 2002).

The SHL Universal Competency Framework (Bartram, 2011) was used to further confirm the proper identification of the individual ECs, and a process of clustering was used (refer to Annexure 2). For the purpose of this study, this framework was also adapted for the second round of the Delphi Study, by using the “Great Eight” competencies’ main competence areas as the first level and the 20 competency dimensions as the second level, as can be seen in Annexure 2. The ECs of the behavioural level as third level were adapted, based on the results from the first round of the Delphi Study. In this way, the framework was built on a well-known framework from practice and research and adapted for the 4IR and specifically entrepreneurs.

The same codes were used in the concept matrix as developed in the Delphi study, using the SHL framework as guideline to categorize the various ECs; 136 ECs (refer to Figure 2) resulted from the literature study and 87 ECs from the Delphi study. Based on the concept matrix, the most cited ECs, which were cited by three or more articles/authors, were identified (33) and summarized in Figure 3.

**Figure 3.** Concept matrix: Summary of the entrepreneurial competencies most mentioned in the literature



Source: Own compilation

This list presented in Figure 3 was compared with the 28 ECs with a mean score of 6.33 and above that had been identified from the Delphi study. Based on the fact that empirical research has been done on ECs that are well known in the literature, the known ECs (most cited, three times or more) were used to eliminate and shorten the list of 28 ECs identified from the Delphi study. The Delphi study results were therefore used as the starting point for the elimination of ECs. In order to avoid the elimination of critical ECs that could be essential for the 4IR, ECs were nevertheless included if they occurred in the most recent research conducted within a five-year period (2014–2018) and were cited at least three or more times.

Six ECs that had already been identified in the Delphi study were also identified in the literature (decision-making capability, problem-solving, creativity, innovation/ innovating, opportunity recognition and cognitive ability). However, five ECs (communication, technical-functional competence, organizing and leading, learning and research ability) were also among the most cited ECs within the five-year period (2014–2018), but had not been identified in the Delphi study, and were therefore not part of the list of 28 ECs for elimination.

As a result of the first elimination process, Table 4 illustrates that 17 well-known ECs were identified in the concept matrix among the most cited (\*) ECs (taking initiative, building and using networks, persistence/perseverance, self-efficacy, decision-making capability, problem-solving, creativity, innovation/innovating, opportunity recognition, critical thinking, need for achievement, interpersonal skills (teamwork), relationship building skills, analytical ability, cognitive ability, innovativeness and individual commitment). At the same time, 11 specific 4IR ECs were identified within the five-year period (\*\*\*) and these 4IR ECs include: positive attitude, proactiveness, value creation, resilience, creative problem-solving and imaginativeness, action-oriented, networking ability, adaptability, ability to overcome stumbling blocks, leadership skills and performance motivation.

The second elimination process took the mean score results from the Delphi study into consideration. There were 14 ECs with a mean score above 6.50. The ECs with a mean score of 6.42 and below were further evaluated (listed as 15–28 in Table 4) and eliminated by a process of only including those ECs that were identified specifically for the 4IR in the concept matrix. Even if the EC was cited only once in 4IR literature, it was included in the final list.

**Table 4. Delphi Results: Identification and elimination of ECs**

First elimination process results	ECs	Delphi results	Second elimination process results
	Competencies	Mean score	Final remaining competencies
*1	Taking initiative	6,67	
*2	Building and using networks	6,67	
*3	Persistence/Tenacity/Perseverance	6,67	
**4	Positive attitude	6,67	1
*5	Self-efficacy	6,67	
*6	Decision-making capability	6,58	2
**7	Proactiveness	6,58	3
**8	Value creation	6,58	4
**9	Resilience	6,58	5
*10	Problem-solving	6,50	6
**11	Creative problem-solving and imaginativeness	6,50	7
*12	Creativity	6,50	8
*13	Innovation/Innovating	6,50	9
*14	Opportunity recognition	6,50	10
**15	Action-orientation	6,42	
**16	Networking ability	6,42	11
*17	Critical thinking	6,42	
**18	Adaptability	6,42	
**19	Ability to overcome stumbling blocks	6,42	
*20	Need for achievement	6,42	
**21	Leadership skills	6,33	12
*22	Interpersonal skills (teamwork)	6,33	
*23	Relationship building skills	6,33	
*24	Analytical ability	6,33	
*25	Cognitive ability	6,33	13
*26	Innovativeness	6,33	
*27	Individual commitment	6,33	
**28	Performance motivation	6,33	

\*Most cited competencies eliminated

\*\*Only 4IR competencies identified (2014-2018)

This resulted in a list of 10 4IR ECs (positive attitude, decision-making, proactiveness, value creation, resilience, problem-solving, creative problem-solving and imaginativeness, creativity, innovation/innovating, opportunity recognition). An additional three ECs (networking ability, leadership skills and cognitive ability) were added to the list of 10 ECs. This process resulted in 13 4IR ECs, after which creativity was merged with innovation, resulting in a final list of 12 ECs, as illustrated in Table 5.

## **Results**

The final ECs resulted by including ECs identified from the Delphi study (17/28) with a mean score of 6.3–6.67; the most cited ECs (3 times or more) (6/17) from the concept matrix; and ECs identified for the 4IR, specifically (7/17), resulting in a final list of 12 ECs, as illustrated in Table 4. Delphi participants therefore felt that the top-rated essential ECs for 4IR with the highest mean scores were: positive attitude (6.67), decision-making (6.58), proactiveness (6.58), value creation (6.58) and resilience (6.58).

Consistent with recent research advocating the importance of ECs for 4IR (Abdullahi *et al.*, 2020), the top-rated essential ECs for 4IR with the highest mean scores were: positive attitude, categorized as a social competence; decision-making, categorized as a cognitive competence; proactiveness, categorized as a cognitive competence; value creation, categorized as a functional competence; and resilience, categorized as a cognitive competence.

### *A Conceptual Framework for 4IR entrepreneurs*

Based on evidence from the two-stage methodological principles applied, the classification into categories of the 12 ECs that were identified resulted in the conceptual framework as presented in Figure 4.

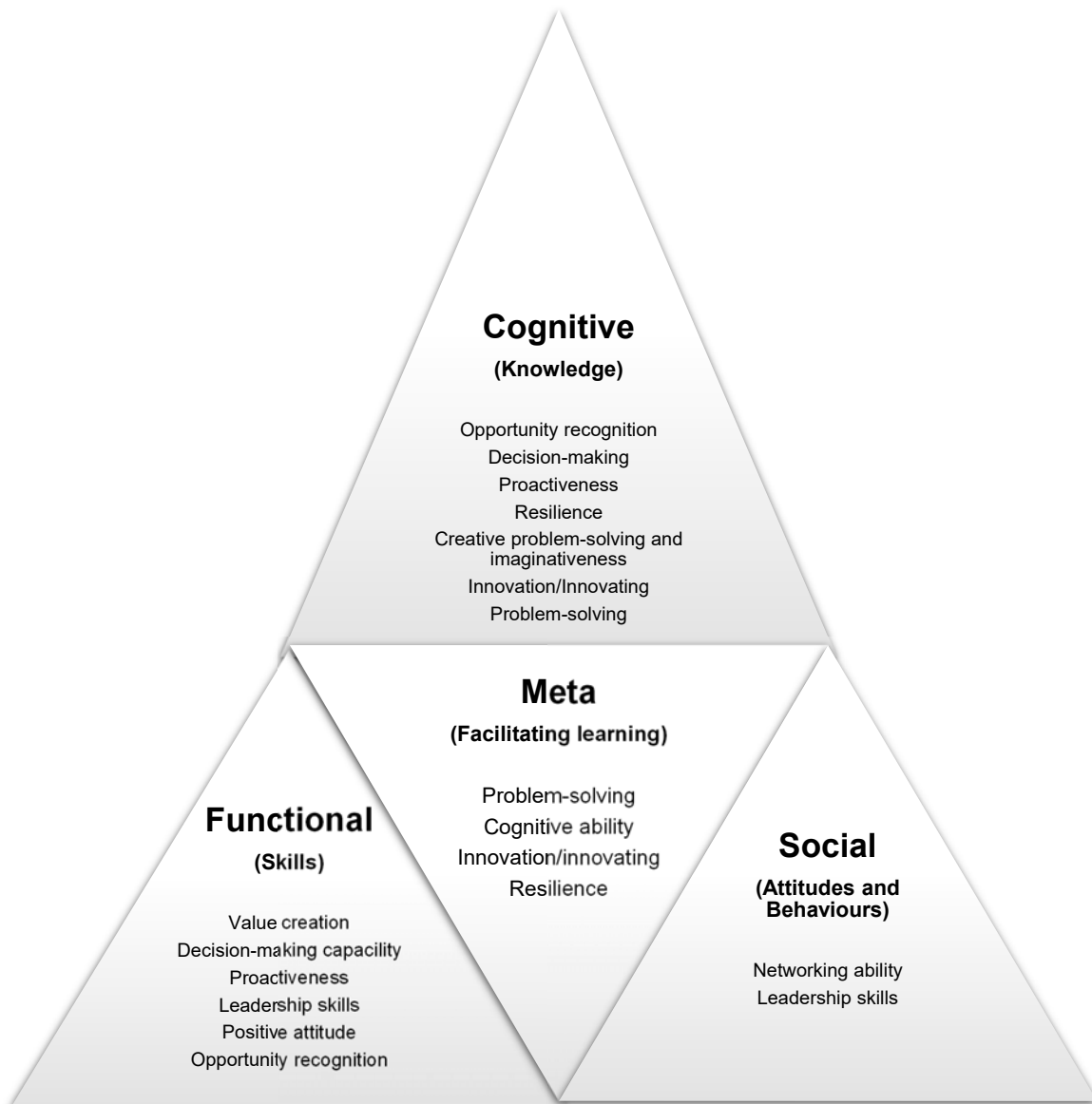
**Table 5.** Summary of the measures employed to assess the final 12 ECs and four categories

<b>Competencies</b>	<b>Mean score</b>	<b>Competence category</b>
<b>Decision-making capability</b>	6.58	CEC and FEC
<b>Proactiveness</b>	6.58	CEC and FEC
<b>Leadership skills</b>	6.33	SEC and FEC
<b>Networking ability</b>	6.42	SEC
<b>Cognitive ability</b>	6.33	MEC
<b>Problem-solving</b>	6.50	MEC and CEC
<b>Creative problem-solving and imaginativeness</b>	6.50	CEC
<b>Innovation/Innovating</b>	6.50	CEC and MEC
<b>Value creation</b>	6.58	FEC
<b>Resilience</b>	6.58	CEC and MEC
<b>Positive attitude</b>	6.67	FEC
<b>Opportunity recognition</b>	6.50	CEC and FEC

Source: Own compilation



**Figure 4.** An Entrepreneurial competency framework for the 4th Industrial Revolution



Source: Own compilation, as adapted from Le Deist and Winterton (2005)

## Discussions and conclusion

The main focus of this paper is to investigate which ECs are required for the 4IR and significant for innovation. A multi-dimensional holistic approach as well as the SHL Universal Competency Framework is used by categorizing the ECs into the four categories which resulted in the conceptual model for the ECs necessary for the 4IR.

Opportunity recognition, decision-making, proactiveness, resilience, creative problem-solving and imaginativeness, innovation/innovating and problem-solving are categorized as CECs, as they all are based on the possession of appropriate work-related knowledge, skills (Omami and Zeng, 2018:4). Therefore, the relative importance of CECs is linked to workplace performance (Boyatzis, 2006). Networking and leadership are categorized as SECs, as they all comprise attitudes and behaviours in work-related situations (Cheetham and Chivers, 1996:24). SECs are known as behavioural ECs (knowing how to behave), defined as a relatively enduring characteristic of a person, causally related to effective or superior performance in a job (Winterton *et al.*, 2006:40). Value creation, decision-making, proactiveness, leadership, positive attitude and opportunity recognition is categorized as an FEC, as it is based on the ability to perform a range of work-based tasks effectively to produce specific outcomes (Cheetham and Chivers, 1996:24). It is also known as skills or know-how – things that a person who works in a given occupation area should be able to do and be able to demonstrate (Winterton *et al.*, 2006). Problem-solving, cognitive ability, innovation/innovating and resilience are categorized as MECs, as they facilitate learning (Cheetham and Chivers, 1996:22:22) and the ability to put the focus on the “know-how” and combine and relate a set of skills in different situations (Arisó *et al.*, 2016:51). MECs are also described as meta-qualities, i.e. creativity, mental ability, and balanced learning skills, which are reinforced by other qualities. They include the ability to cope with uncertainty, as well as with learning and reflection, and also individuals’ knowledge of their own intellectual strengths and weaknesses, how to apply skills and knowledge in various task situations and how to acquire missing ECs (Winterton *et al.*, 2006).

Although there are no additional ECs identified in this paper that enhance IC, emphasis was placed on technology use and development and the integration of business technological skills as important 4IR ECs. Interestingly, technology use and development, as well as integration of business technology skills, are not included after the elimination process in the final conceptual framework presented in this paper. As a developing country, we are still far behind in terms of 4IR and have much to learn from first-world countries. In terms of international comparability,

it is interesting to note that the findings of this study are to a large extent in line with the results of related international findings regarding 4IR ECs. For instance, ECs identified in this study were also identified as 4IR ECs in other countries which investigated this phenomenon, such as decision-making (Grzybowska and Łupicka, 2017; Prifti et al., 2017), problem-solving (Prifti et al., 2017), innovating (Prifti et al., 2017), networking (Erol et al., 2016; Prifti et al., 2017), leadership (Prifti et al., 2017) and cognitive ability (Erol et al., 2016; Prifti et al., 2017). Gray (2016:19) identified ten skills the workforce needs to thrive in the 4IR. A comparison was made between the skills that were required in 2015, compared with the skills required for the workforce of 2020, of which emotional intelligence and cognitive flexibility were identified as two of the new skills needed. Hence the inclusion of cognitive adaptability as one of the ECs identified in this paper.

Based on the 33 ECs identified in the concept matrix and list of 24 articles (Annexure 3) that are from earlier studies (1992–2016) (article 1-19), ECs typically prior to 4IR are: managerial competence, opportunity recognition, need for achievement, creativity, problem-solving and networking (Chandler and Jansen, 1992; Hisrich, Peters and Shepherd, 2005; Man, Lau and Snape, 2008; Botha *et al.*, 2015b). In the articles included after 2016, it is clear that cognitive adaptability and conflict solving are included as important ECs.

The contribution of this paper is fourfold. Firstly, by utilizing the multi-holistic competence approach (Le Deist and Winterton, 2005) to categorize ECs, the entrepreneurial competency framework for the 4IR managed to illustrate the specific category of competence that each EC falls under. This was previously extremely unclear and not specified in most entrepreneurial competence frameworks. Focusing on the entrepreneur as a key factor in Industry 4.0, a broad spectrum of ECs was identified from a cognitive (knowledge), functional (skills), social (attitudes and behaviours) and meta (facilitating learning) perspective. Secondly, the results in this paper further the development of the person-entrepreneurship-fit theory. The extent to which entrepreneurs are higher in a number of distinct individual ECs, as Markman and Baron (2003) indicated, the greater the likelihood or magnitude of IC of entrepreneurs.

Thirdly, the importance of the EC framework developed lies in entrepreneurship training and development, with a focus on educators in higher education and entrepreneurial institutions such as entrepreneurship centres and incubators. The various ECs under each of the four categories can be trained and developed according to the most effective learning style of each category. For example, the ECs under CEC should be trained and developed as part of workplace performance, whereas the ECs under MEC should focus on learning and reflection,

and also individuals' knowledge of their own intellectual strengths and weaknesses. These collective ECs, seen as an important synergetic combination of individual ECs, are therefore critical to develop for an entrepreneur to meet a certain level of competence, which is known as the ability to accomplish a work task up to a recognized standard (Matthews and Brueggemann, 2015:11). The final contribution of the study lies in providing business owners with knowledge about the business's ability to integrate, build and reconfigure internal and external ECs to rapidly changing environments. From a supply side, a competitive advantage can only be achieved if an entrepreneurial organization has the ECs to serve the market more effectively than its competitors. This can be achieved by means of integrating knowledge, rather than just having the knowledge. South African entrepreneurs intending to compete in the global market have important practical implications to consider, particularly regarding their capacity to innovate in the 4IR. These entrepreneurs can focus on enhancing the 12 ECs as identified in this paper, as significant ECs for IC and the 4IR. Specifically, entrepreneurs in developing countries need to effectively prepare for this industrial revolution and also the next. Entrepreneurs will therefore require continuous learning across multiple disciplines to be able to adapt an entire business, innovate in rapidly changing environments, and enable effective coordination between components (Vendrell-Herrero, González-Pernía and Peña-Legazkue, 2014; Hermann, Pentek, Otto, Pentek and Otto, 2015).

### *Limitations and future research*

Firstly, the inadequacy of studies on 4IR ECs among entrepreneurs in developing countries, specifically South Africa, was limiting in the review of literature. Therefore, international studies were considered as a point of reference and ECs and innovative capacity literature were used in general. This resulted in limited studies that focused on individual ECs. At the time of conducting the research in this paper, the majority of the studies included in the concept matrix were published before 2016. It is recommended that the concept matrix be repeated by including articles from 2020 onwards. Future research can attempt a comparative study between the EC list and categories identified in this paper and that of others in developed countries, specifically focusing on IC and 4IR ECs. Secondly, it is important to note that other Delphi and literature review studies could identify further possible ECs required for the 4IR. Therefore, it is imperative to empirically test the conceptual framework developed in this paper. This could be done by conducting a longitudinal study to determine whether the ECs identified in this paper enhanced the IC for 4IR entrepreneurs. Lastly, other ECs identified from the

Delphi study that were not tested included: taking initiative, persistence, perseverance, critical thinking, the need for achievement, interpersonal skills, teamwork, relationship building, analytical ability and individual commitment. From the most cited ECs that were not included in this study were: communication, technical-functional competence, organizing and leading, learning and research ability.

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