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ORIGINAL ARTICLE

Entrepreneurial Self-Efficacy of Scientists: A qualitative study on ATTRACT Phase 2 R&D&I Ventures

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Abstract
We need to understand the antecedents of entrepreneurial self-efficacy (ESE) of actors in science and technology-based commercialisation when we want to foster the commercialisation of scientific innovations. Despite the plethora of research on ESE in general, research on antecedents of ESE of scientists is scarce. Yet, there is reason to believe that because scientists develop a scientific self-efficacy, the antecedents to scientists' entrepreneurial self-efficacy differ from the ESE antecedents of other target groups. Therefore, we explored which ESE antecedents resonate with a unique cohort of scientists and how attributes such as cultural and institutional factors, firm capabilities, education, work experience, role models, and individual differences support the building of entrepreneurial competence. This study provides practical relevance to educators and science entrepreneurs, identifying a need for tailored education for science and technology-based entrepreneurship to foster the development of a dual self-efficacy that reflects scientific norms and commercialisation needs.

Keywords: Science self-efficacy; entrepreneurial self-efficacy.

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INTRODUCTION

Self-efficacy is pivotal in fostering entrepreneurial activity (Miao et al., 2017). Individuals possessing high levels of self-efficacy are motivated by goal-setting behaviours, exhibit dedication to action, and gravitate towards challenging activities (Trevelyan, 2011; Wood & Bandura, 1989). Entrepreneurial self-efficacy (ESE) involves believing one can perform a task. It is also a critical success factor for maintaining motivation, utilising resources, and effectively responding to situational demands (Chen et al., 1998; Newman et al., 2019a; Wood & Bandura, 1989).

Despite evidence of the role of self-efficacy in fostering entrepreneurial activity, research on the self-efficacy of the entrepreneurial scientist as a particular target group is still emerging (G. Chen & Bliese, 2002; Newman et al., 2019b). ESE is particularly important in transitioning from research knowledge to entrepreneurial expertise. A transitional process is necessary to develop an impact on science and stimulate technology transfer from research to commercial environments. It necessitates a self-regulated understanding of acquiring potentially new entrepreneurial knowledge, skills, and attitudes (Goethner et al., 2012).

The question that guides this research is ***'What are the antecedents of entrepreneurial self-efficacy of scientists?'***

We use a self-assessed perception of entrepreneurial competencies to investigate the relationship between perceived ESE and scientists acquiring new skills to commercialise scientific innovation. Through the lens of Newman et al.'s (2019) six antecedents of ESE, we provide insights into how scientists build their entrepreneurial competence when aiming to commercially close the gap between scientific knowledge and the market (Newman et al., 2019b).

CONCEPTUAL BACKGROUND: ESE AND ESE FOR SCIENTISTS

Self-efficacy is defined as an individual's belief in his or her abilities to perform a task successfully (Bandura, 1977, 1990). Specifically, ESE is the belief in the ability to perform entrepreneurial tasks. ESE is a key attribute to understanding what motivates and influences an individual to engage in entrepreneurial activity, ultimately influencing their behaviour and performance when commercialising scientific innovations (Chen et al., 1998; Goethner et al., 2012; Obschonka et al., 2019). Further, scholars argue that individuals with high ESE have a positive mental state toward uncertainty (Engel et al., 2014; Uygur & Kim, 2016) and that high levels of ESE encourage goal setting and the commitment to tasks and actions (Cardon & Kirk, 2015; Trevelyan, 2011).

Antecedents to ESE are those factors that influence the degree to which a person attains ESE. Based on an extensive body of literature, Newman et al. (2019) categorize a set of six ESE antecedents namely: cultural and institutional environment components, firm characteristics, education and training, work experience, role models/mentors, and individual differences (Newman et al., 2019b). The benefit of the Newman et al. (2019) framework is that it is comprehensive and based on ESE studies on a large variety of populations. Yet, it does not indicate whether the ESE of scientists may have different antecedents.

Antecedents to scientists' ESE may differ because scientists have already developed a form of self-efficacy as part of their training as scientists. Science is marked by autonomy, independence, and a continuous search for scientific challenges. Their scientific self-efficacy resonates with entrepreneurial self-efficacy but is still quite different. It focuses on fixed internal goals and take shape in a predefined set of scientific outputs, whereas entrepreneurial self-efficacy focuses on external goals that are uncertain, not fixed, and pluriform.

LITERATURE REVIEW

To identify the research on ESE antecedents for science, technology, engineering, or mathematics (STEM), we conducted a literature search (in SCOPUS) using the keywords "entrepreneurial AND self-efficacy" and "science", and we identified 14 publications. Upon closer examination, we found that three articles were irrelevant to STEM education or commercialisation, and these papers were excluded.

The remaining articles fell into two main categories: those focusing on university student environments and those examining professional STEM environments. Studies in the professional domain investigated various topics, such as the influence of gender on ESE development among early career STEM researchers (Achtzehn et al., 2023), the impact of COVID-19 on micro-entrepreneurs in the Pakistan ICT sector (Sardar et al., 2021), and the effects of entrepreneurship education on the scientific community in Mexico (Barron & Amoros, 2019).

The studies related to student environments shed light on how ESE influences entrepreneurial intentions, its role in assessing students' readiness for start-ups (Adeniyi, 2023), different types of entrepreneurial learning (Barth & Muehlfeld, 2022; Chang et al., 2016; Elliott et al., 2020; Naktiyok et al., 2010; Sesen, 2013; Shao-hui et al., 2011) and the outcomes of developing ESE (Yun, 2010). Additionally, one study explored how ESE contributes to project performance among students enrolled in entrepreneurial programs (Shekarian & Parast, 2021).

Within the Newman et al (2019) study on entrepreneurial self-efficacy, the scholars searched 128 published literature papers from 1998 to 2017 to understand the theoretical foundation of ESE, and how it can be used to measure entrepreneurial belief, including what precedes having such belief (Newman et al., 2019b). The systematic review found that previous research was fragmented and from diverse backgrounds. The scholars contributed to the literature by providing a synthesized framework of six antecedents to ESE, and how entrepreneurial intentions, and an individual's mental state led to entrepreneurial behaviour and performance (Newman et al., 2019b).

This underscores the scarcity of research on ESE in science and technology, highlighting the need for further academic attention. This observation is consistent with a study by Tiberius et al. (2023), which conducted a systematic review of entrepreneurship education and found that only 8% of published studies were relevant to the STEM domains (Tiberius & Weyland, 2023).

METHODS

We used a mixed methods study to identify which antecedents scientists draw on when they build ESE (Tashakkori & Creswell, 2007; Terrell, 2012). The quantitative phase was used to assess the level of ESE by our population. The qualitative phase was used to explore the antecedents scientists draw on when they develop ESE. This was done through individual interviews with the same cohort of participants (Creswell & Garrett, 2008).

The study context was scientists within the ATTRACT R&D&I Phase 2 cohort. Attract R&D&I Phase 2 is a European Union's Horizon 2020 programme. This program is aimed at scientists who want to commercialise their innovations. In this program, scientists are supported in developing their innovations from Technology Readiness Level (TRL) 4 to 7. This means that when a technology is at level 4 it's functional in a laboratory environment and when it's at level 7 it can operate in an operational environment of the targeted user (Bruno et al., 2020).

This study context is ideal for the study of scientists' ESE antecedents because we are dealing with professional scientists who have proposed a scientifically researched innovation for society, and upon acceptance into the ATTRACT Phase 2 release, nearly all R&D&I projects have the same scientific starting point at TRL 4 and end target at TRL7. This may reduce the variance in initial ESE held by scientists who enter the commercialisation environment.

In the initial quantitative phase, we assessed the perceived level of entrepreneurial competence within the cohort. To achieve this, the participants were asked to rate their level of satisfactory performance across a range of entrepreneurial competencies. We used the Entrecomp framework (Bacigalupo et al., 2016), which lists 15 competencies in three categories (ideas and opportunities, resources, and action). The respondents were asked, based on a 5-point Likert-type, to rate their perceived ESE after 12 months into starting Phase 2.

The more emphasised step for this exploratory study focused on a qualitative phase aimed at uncovering the factors that influence the participants' perceptions and experiences related to how their ESE has developed over the time of the project. Questions were related to the process and sources for developing their perceived entrepreneurial competencies and, thus, to how their ESE has developed. Thematic coding involves identifying recurring themes in the responses and organising them according to the six antecedent categories (Newman et al., 2019c).

RESULTS

First, the degree of ESE was assessed by averaging the self-assessment of the entrepreneurial competencies. The results confirm that scientists have encountered the 15 entrepreneurial competencies whilst taking entrepreneurial action in their duties on the commercialisation project. Scientists were asked to rate their performance satisfaction level for each of Entrecomp's 15 individual competencies. Ratings provided a score for each competency category, namely ideas and opportunities, resources, and action. Average scores were computed for each category, then an overall average was obtained by summing the individual scores of each participant. All participants' average scores were higher than 3.88 out of 5, suggesting a high degree of ESE.

Secondly, interviews were held with each participant. Using the antecedent framework from Newman et al. (2019), Table 1 illustrates the results of thematic codes used to identify which antecedents to ESE the scientists claimed to have influenced their ESE development.

The results showed that scientists are not drawn to using the entrepreneurial culture of commercialisation nor the performance-based expectation to reach TRL7 when building their entrepreneurial belief in their profession.

The results did indicate that the most common antecedents to how scientists build their entrepreneurial competence were their reliance on how work teams are structured (firm characteristics), the level of vicarious learning (education and training) that takes place during the commercialisation process, and the utilisation of mentors or role models. Only two scientists placed importance on prior entrepreneurial exposure and experience in the industry as reasons to have a high belief in their entrepreneurial ability. Finally, one scientist displayed a preference for entrepreneurship, such as a risk-taking preference indicating the tolerance to develop entrepreneurial self-efficacy.

Drawing on the six antecedents of ESE in the Newman et al. (2019) framework, the comments from the interviews were analysed to group the themes.

Firm characteristics for scientists in commercialisation projects refer to how scientists rely on the day-by-day structure of the operational team. Further, interview evidence reflects that involving team members in decisions supports the further progress of entrepreneurial exposure.

P (1) noting *"I don't pursue an entrepreneurial career, I'm not sure if I can find that useful. I don't like it. It it's better that there are people who like it and who are super good at it. So that's very good. To have them in the team"*.

As with comments received from P (6) *"I think from my own personal benefit, I have a lot of resources internally and my organisation"*.

External partners also act as a source of persuasion and entrepreneurial learning with P (12) indicating *" we do things together and that's basically how we learn most of the stuff you know nowadays"*.

Education and training form part of the experience to build ESE, commercialisation provides entrepreneurial opportunities to master experiences, and the environment opens opportunities for scientists to learn by doing and to be influenced by social persuasion. This provides opportunities for vicarious learning to take place by being part of live cases and learning from others in action.

(P2) indicated, "*I learn a lot by meeting with companies... so, I talked to multinational pharmaceutical companies, venture capital companies, several of them, [including to] large startup companies*." More formal learning is heard from P (3) who attests to joining "*various webinars and training on intellectual property...value proposition and business model canvases*" but also highlights returning to "*work piling up",* reflecting that having no time to "*really have any time to consolidate what we are going through. That was the unfortunate bit about* it".

In other instances, as noted by P (5), "*learn[ing] a lot by doing and looking around*" is the preferred manner to learn. While P (9) refers to wanting to improve skills that are specific to the needs of the current entrepreneurial activity, stating "*I want to improve my skills on something, I would not do it out of the blue*", and P (13) acknowledges to be in a learning curve during commercialisation but does not "*foresee like a high structure [d course] like an MBA*" to be required.

Role models and mentors refer to the third most identified antecedent to building ESE. Here scientist P (3) aligns with the antecedent to learn from others, attesting "*we need to go to partners... to provide those technical gaps*" and how being "*in touch with people that could help to make [us] that transition*". Role models serve to close the gap, admitting that "*without* *mentorship [studying things], then you are doomed to make too many mistakes*" P (6).

Table 1. Participant preference for learning about entrepreneurship, structured based on the Newman et al. (2019) antecedent framework of ESE.

Participant **Newman et al (2019) antecedent**	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Culture and institutional environment														
2. Firm Characteristics	X					X		X	X			X	X	X
3. Education and training		X	X				X		X	X	X	X		
4. Work experience				X									X	
5. Role models / Mentors		X		X	X					X			X	
6. Individual differences			X											

One scientist stressed the importance of receiving advice and having resources to assist in solving problems, claiming, "*It is essential to have a network of people*" P (7).

Similarly, but in a different way, P (2) utilises a business coach to execute operational tasks and notes that "*consulting with him, he is part of the team. He discusses everything with us*" as being beneficial to growing confidence in executing entrepreneurial tasks. Another example is the preference to strategically find a commercial partner with relevant expertise, highlighting that as a scientist, "*we cannot be CTO of the company and we can have a CEO*" P (4).

Individual differences: according to the work of Newman et al. (2019), antecedents also include a personal preference for risk-taking and having a personality style towards entrepreneurial passion. This was only found in one instance P (5), who learns by doing but also from "*culture, by history and by, let us say, attitude" and understanding entrepreneurship is about "mostly is an understanding [the] dynamics*".

DISCUSSION

This study addresses the gap in the literature regarding the development of ESE with a particular focus on science and technology commercialisation projects. Entrepreneurial competence is considered an integration of knowledge, skills, and attitudes (Lizzio & Wilson, 2004). The development of such aspects is a transformative process through which scientists evolve their self-efficacy into a distinct set of competencies to achieve commercialisation success (Baartman & De Bruijn, 2011).

The lack of an identifying culture and an institutional environment as an antecedent to building ESE suggests that scientists may not prioritise or perceive performance-based goals such as striving to reach TRL 7 as a motivator to strengthen their ESE. This implies a potential blind spot in their understanding to explore a broader ecosystem within which entrepreneurship operates in a commercialisation ecosystem.

Further, results indicate that scientists have a willingness to learn through various training initiatives despite their perspective on time constraints. Demonstrating a proactive nurturing of their development of ESE. The equally important use of role models, alongside this informal entrepreneurial education and training initiatives, evidences the need for scientists to be self-regulated and aware of informal learning opportunities or events such as topical webinars, short entrepreneurial courses, or presentations by experts. It further highlights the need for tailored educational interventions that consider the scientists’ high level of entrepreneurial belief but support the gaps in a scientist's entrepreneurial development. Overall, the quotes highlight the multifaceted approach to developing ESE for a scientist, drawing on a combination of personal experiences, learning opportunities, and external support systems aligned with the Newman’s framework (Newman et al., 2019b).

Our agenda for future research suggests that scientists should adopt a multi-faceted approach to developing ESE. Although scientists draw on various antecedents of ESE, they also rely on their scientific self-efficacy to commercialise innovation. Future research could better understand why scientists do not leverage the culture and institutional environment to develop their entrepreneurial competence further.

Understanding the unique way scientists navigate utilising of resources, constraints, and time pressure could provide insights into how effective mentorship can practically assist in developing entrepreneurial action. The development of a dual competence in the scientists' ESE appears to be intricately linked to their ability to integrate their scientific skills with their developing entrepreneurial skills, indicating the importance of dual self-efficacy.

This exploratory understanding influences the design of targeted educational programs aligned to identified antecedents and entrepreneurship education learning preferences. An example of this is the benefits gained when learning from experienced and successful role models who offer mentorship and feedback on decisions. Others include deliberately creating workplace opportunities for mastery and vicarious learning to take place organically, leveraging support initiatives, and encouraging interdisciplinary team decision-making.

CONCLUSIONS

To conclude, this research reveals that scientists use a specific mixture of antecedents in developing ESE. Educators in STEM entrepreneurship education can tailor programs to scientists' preferences, specifically leveraging role models and providing entrepreneurial supportive work environments where scientists can network.

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