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Minireview

MINIREVIEW – Professional Development

Innovative training networks: overview of the Marie Skłodowska-Curie PhD training model

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One sentence summary: This article explains the key features of EU-funded PhD training networks to provide readers with an understanding of the similarities and differences with other types of PhD training.

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ABSTRACT

Doctoral training has changed in recent years with most PhDs now performed in structured programmes operated by university graduate schools. These schools generally superimpose a training framework onto the traditional research project to improve the education experience of the students and to prepare them for their careers. Many graduates progress to the commercial sector, where there is demand for highly skilled employees. The European Union (EU) promotes the development of transnational, training-focused, PhD programmes called Innovative Training Networks (ITNs) through Marie Skłodowska-Curie Actions. ITNs share many features of thematic PhD programmes, but they only recruit a single cohort of students, and they align with EU policy goals. These training networks are prestigious and very well regarded within European academia. The authors of this article were participants in a yeast biotechnology ITN, YEASTCELL, which finished in 2017. Some interesting insights into the more and less successful aspects of the project arose during discussions at the final project workshop. The views of the participants are distilled here in a discussion of how an ITN could be structured to maximise the benefits for the three main stakeholders: students, supervisors and industry partners.

Keywords: PhD; Marie Skłodowska-Curie Actions; ITN; career; training; H2020

MARIE SKLODOWSKA-CURIE ACTIONS

For just over 20 years, the European Union (EU) has been funding PhD training under the Marie Skłodowska-Curie Actions (MSCA) banner (European Commission, 2018). These Actions support training for researchers at all stages of their career and, by 2017, over 100 000 researchers had participated in MSCA (European Commission, 2017). MSCA are an instrument of EU policy and there is a keen emphasis on researchers' rights and professional development. Programmes are required to adhere to the EU Code of Practice for Researchers (European Commission, 2005) and must adhere to professional recruitment and employment standards for PhD students or 'Early Stage Researcher' (ESR) in the language used by MSCA. In some European countries, such practices are already the norm, but, in others, MSCA serves as an exemplar of best practice in PhD training that can be emulated with national programmes. The majority of PhD training under MSCA is provided in Innovative Training Networks (ITNs), which are consortia of industry and academic partners that come together for a four-year period to provide a bespoke research and training programme on a particular topic. ITN funding calls are structured in such a way that applicants can select the research topic to match their own interests. This 'bottom-up' approach makes them very attractive to academics and allows

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industry to have input into research direction. Nonetheless, since an ITN is, at its core, a PhD training initiative, applications for funding are evaluated and approved on the basis of excellence with respect to both research and training. Proposals must demonstrate the positive impact that the programme will have on the career of the PhD student, on European doctoral training in general and on European innovation capacity. Many of the aspirations of MSCA for the delivery of PhD training in Europe are embodied in a policy document entitled the Seven Principles of Innovative Doctoral Training (European Commission, 2011). In an ITN, in addition to a PhD research project, ESRs take courses and training modules in diverse topics, complete secondments with academic and industry partners, and participate in outreach and engagement activities. Training often includes core and advanced research skills related to the field of study, innovation and enterprise skills, communication and workplace skills, and knowledge of responsible research and innovation. These activities are planned and monitored within each ESR's Personal Career Development Plan, which they create and update with their supervisory committee. Many of these elements are included in other national or international programmes, but an important feature of ITNs is the mandatory inclusion of all these components. The international dimension is also very specific to ITNs, with all programmes comprising partners from at least three countries, and more typically six to eight. Furthermore, international mobility is mandatory and all ESRs must be recruited to a country where they have not been living or studying. Participation places serious demands on all members and the configuration of an ITN and the attitude of each participant play a major role in determining its effectiveness. Successful implementation of an ITN requires a shared understanding by all participants of the goals of this type of PhD training. These can conflict with the traditional understanding of the nature of a PhD and the rationale for undertaking doctoral research.

ROLE OF INNOVATION-ORIENTATED PHD TRAINING PROGRAMMES

The core missions of a university, education and knowledge generation converge on doctoral training, whereby a student carries out a research project for three to four years under academic supervision, writes a thesis and after defending it successfully, receives a PhD. New knowledge is generated and the student and supervisor are likely to publish some of the research findings in peer-reviewed journals. This traditional model is suited to pursuing an academic career but there has been much debate in recent years as to whether it is the most appropriate model in modern times, given the likely career paths following a PhD. More specifically, it is evident that many more PhD students are being trained than are required to fill academic vacancies and nowadays, fewer than 20% of PhD graduates will remain in academia; most will pursue research careers in industry or diversify into areas like policy and administration (Gould 2015; Singh, Gammie and Lorsch 2016). Indeed, the number of PhDs awarded in Organisation for Economic Co-operation and Development (OECD) countries grew by almost 40% between 1998 and 2008, leading some to question whether we actually need all these PhDs and whether people are being trained for careers that do not exist (Cyranoski *et al.* 2011). As a counterpoint, many countries with ambitions to build 'knowledge-based' economies have policies aimed at increasing the number of PhDs, and there are good data showing that more advanced, high-value economies have higher number of PhDs in the workforce (OECD 2016). Furthermore, in support of the benefits of PhD-level training, a recent study of the careers of almost 5000 PhD graduates in the UK and Canada provided empirical data confirming that PhD holders have strong, diverse career prospects (Woolston 2018). This is backed up by employers who believe that PhD training equips graduates with a broad set of valuable transferrable skills (Fiske 2016). It is implicit in the concept of a PhD that the graduating student will have the potential to further their academic career by pursuing post-doctoral research and later securing a research position; no PhD training programme should lose sight of that possibility. However, this is not the primary reason why the EU or other public bodies provide funding for increasing numbers of PhD training programmes, nor why industry partners wish to become involved. For them, the purpose of a PhD training programme is to train researchers who can bring innovation out of the universities and into society. It is also true that the traditional rationale for training PhDs, to create knowledge and expertise within the academic system, is not the end goal for many students. For PhD training to be effective, it must provide graduates with the appropriate skills to create or exploit the opportunities available to them on graduation. Knowing this, there has been a concerted move towards offering PhD students training in transferrable skills that can be applied in multiple sectors, not just academia. PhD students also need to understand why they have chosen to pursue a PhD and what type of training they desire. It is worrying that the responses of ~5700 PhD students to a survey in the journal *Nature* indicated that a large number of university graduates do not understand the range of training programmes available and are unable to select the programme that best suits their needs and career aspirations (Woolston 2017).

INTEGRATING INDUSTRY PARTNERS INTO AN ITN

It is obligatory to include industry partners in an ITN either as a beneficiary, where they recruit a PhD student, or as a partner organisation, where their main role is in hosting internships or secondments. It is important that both industry and academic partners understand that their primary objectives of participation are likely to be different but are also willing to work at finding a common ground. As has been highlighted in other studies of industry–academia cooperation, failure to recognise these differences can jeopardise the entire working relationship (Pronk *et al.* 2015). It follows that sufficient time must be spent at the proposal planning stage to build a solid network, in which members have aligned research interests, a commitment to the scheme and a spirit of open collaboration. The starting point for most ITNs is a desire by a number of academic partners to develop a research programme with shared overall objectives. It is important to give industry partners direct input to the design of this research programme, even when their role might be limited to hosting an ESR for a relatively short period. Keeping the focus on basic and pre-competitive research avoids potential issues around intellectual property rights and generally secures stronger industry engagement with less potential for conflicts of interest. For companies, the best reasons to participate in an ITN are to be part of an excellent network and ecosystem, to have access to new research ideas and techniques, to have the potential to orientate training towards the type of personnel they require and to secure the opportunity to recruit highly qualified new staff. There is the possibility of generating valuable results, products or intellectual

property (IP), but this should be a secondary consideration. The value of a strong partnership cannot be overstated and the benefits from the resulting networking opportunities are always cited as one of the enduring legacies of ITNs (Morrissey 2017; Weinhold, Mast-Gerlach and Meyer 2017).

SPECIFIC CHALLENGES OF THE ITN MODEL

An ITN, by its nature, is a network of participants distributed across Europe, which could lessen the impact of the research collaboration where interactions between participants are not supported (Lee *et al.* 2010). Thus, while face-to-face meetings and training events are vital to developing a strong network and effective collaboration, it is also necessary to manage the time spent travelling and the workload associated with meetings and training events. Technology can be used to provide some training and interaction, for example online journal clubs, seminars and webinars. Every trip bears a cost of time re-engaging with research on return to the lab, so juxtaposing events, for example Summer Schools and transferrable skills workshops, reduces the amount of time lost to research. In addition to the heavy workload and tight time schedule (which will seem familiar to many PhDs), the mobility rules in an ITN mean that the ESRs are required to move countries to be eligible for the programme. They also often have to change countries, or at least cities, again to complete their secondments within the project. As in any structured PhD programme, there is a tension between the requirements for training and the need to generate research outputs. There may be a concern that research performance in an ITN will be lower than in a PhD with fewer training or mobility obligations. However, the interim evaluation of H2020 found that MSCA had higher publication outputs than any other part of H2020 (European Commission, 2017). Arguably, the professional development training offered in an ITN is applied by ESRs to enhance their performance during their PhD. To allow time to achieve satisfactory research outputs, it is necessary to carefully manage the balance between local training in graduate schools and network training provided by the ITN. Active engagement with local graduate schools early in the process can help to alleviate the frustration of unnecessary training duplication. In this regard, mutual recognition of training remains an issue, since not all institutions use the European Credit Transfer System for post-graduate training and only some allow inclusion of short training units (e.g. a 0.5 European Credit Transfer System course). It is worth including a clause in the consortium agreement to recognise and accredit network-provided training at all academic partners to pre-empt administrative obstacles that may arise. By defining skills gaps, personal and career goals, and the local training available at home and network institutes in the Personal Career Development Plan, it ensures that the training, although burdensome at times, remains relevant to the ESR and allows each to work towards their goals.

CASE STUDY OF THE YEASTCELL ITN

The YEASTCELL ITN (https://yeastcell.eu/), which ran from 2013 to 2017, trained 11 ESRs in the field of yeast biotechnology. The training consortium comprised universities (six), research institutes (three), large companies (two) and small or medium sized enterprises (SMEs) (two) with a research goal of developing the biology and technology of industrial yeasts to improve the capacity for exploitation for commercial biotechnology. More specifically, individual ESR projects fell into the categories of beverage biotechnology or industrial biotechnology. Through team supervision and collaboration in shared work packages, ESRs were able to take full advantage of the facilities and expertise available throughout the consortium. New collaborations were built, some foreseen at the beginning of the project and others that were not anticipated. In terms of research outputs, by the time of submission of this article, there were 30 peer-reviewed research papers published by ESRs, 12 of which were joint between 2 or more teams and 7 of which included industry participants. IP has been filed in relation to one of the projects and prototype yeast strains developed in another are being commercialised. These outputs illustrate the capacity for ESRs in an ITN to deliver substantial research metrics while still participating in a comprehensive training programme.

This training programme centred on three core skills sets: research, innovation and transferrable skills. Annual summer schools were dedicated to training in topics that were related to the wider field of the ESRs' research projects, with more specific training delivered in the local graduate school. One relevant conference per year was designated as a YEASTCELL conference where all the ESRs attended and submitted abstracts and in the final year of the ITN, the consortium organised an international conference that also allowed ESRs to showcase the outcomes of the project (http://microb.io/ISSY33). These face-to-face meetings were interspersed with online journal clubs and doctoral presentations. Workshops devoted to commercialisation of research, entrepreneurship, start-ups and intellectual property broadened the ESRs' training to consider careers other than academia. According to YEASTCELL's industry partners, on-the-job, intersectoral training was very valuable in giving the ESRs an opportunity to learn a more industrially oriented way of thinking that includes corporate sensitivity. These concepts, which feed into the sphere of transferrable skills, were reinforced with training in personal effectiveness, research leadership, conflict management and responsible research and innovation. ESRs also received training and participated in public engagement activities.

In some respects, outreach and public engagement was the most difficult aspect of YEASTCELL to organise and manage. The capacity of scientists to engage with people outside of their traditional professional and social network is increasingly important and the skills and practice of doing this are obligatory components of MSCA ITNs. In YEASTCELL, outreach took two forms—activities led by the project team and those conceived and implemented by the ESRs themselves. Although both were successful, feedback from ESRs was much more positive about events that they organised themselves. One example of a top-down engagement activity was a yeast biotechnology blog written by ESRs on a rotation, which recorded 64 000 hits. An ESR-inspired activity was use of knowledge of yeasts to brew a 'wine-inspired' beer that won a university-run home-brew competition. One very successful event that managed to combine these things was a public yeast biotechnology exhibition held in Cork to coincide with the scientific conference (http://microb.io/ISSY33) that was organised as a final network event. The 'Beer, Bread and Biotech' exhibition (https://yeastcell.eu/beer-bread-and-biotech-cork-280617/) was centrally organised and ESRs were invited to contribute. Several participated in different ways: two ESRs used their flair for presenting information visually to prepare material on the history of brewing yeast; another ESR had a particular interest in wine yeasts, and used this to communicate very engagingly with the public—including samples where the influence of different yeasts could be demonstrated (Fig. 1). It was a great success in

Figure 1. Active engagement with the public is a requirement in ITNs. D. Ferreira, one of the YEASTCELL ESRs, pictured at the 'Beer, Bread and Biotech' exhibition in Cork (2017) describing how two wines, identical except for the production yeast, can have different tastes and aromas.

communicating yeast biotechnology research to the public in an engaging and effective way because the ESRs played to their individual strengths and interests rather than feeling pressured into a task to which they did not feel well-suited.

CONCLUSIONS

It is indisputable that pursuing a PhD in an ITN, or other structured PhD programme, is different to how PhDs were undertaken in the past. However, the research context is also very different—modern research is interdisciplinary and technology-dependent, PhD students work in collaborative research teams, the duration is time-limited, students are often paid a salary and there is public accountability for research. More importantly, there is an onus on universities to ensure that graduates, in this case PhDs, receive the best education for their future careers, which for most will be in a non-academic sector. As highlighted elsewhere, PhD graduates must be high-level critical thinkers with a wide set of skills in addition to their specialist know-how (Bosch and Casadevall 2017; Bosch 2018). This does not mean that research is compromised and, although alternative views on PhD assessment have been put forward, it is still the universal case that the award of a PhD is based on production and defence of an independent body of research (Gould 2016).

MCSA ITNs include a rigorous training programme for researchers starting their research careers. ESRs who successfully complete PhDs in an ITN are highly sought-after scientists in the public or private sector. An awareness of this, coupled with an attractive PhD salary (all ESRs have full employment contracts on EU rates), make securing a place on an ITN very attractive for any researcher contemplating the next step in their career. The breadth of these programmes and the demands placed on ESRs, however, should cause self-reflection prior to opting for this PhD route. Ambition and drive are prerequisites for success, but so also is a reasonable level of resilience and personal maturity. The mobility dimension alone demands this, given that an ESR will relocate to a new country to start their PhD, and move twice more for secondments during the PhD. The cohorts of ESRs assembled in ITNs are always high achievers, which creates a healthy degree of competition as well as tremendous potential for collaboration. The most successful ESRs will embrace both aspects and thrive in this environment as they take advantage of the training and opportunities offered. For supervisors and industry partners considering ITNs, careful assessment is also needed as they must also provide substantial inputs over the full duration of the ITN. All those who participate in ITNs, however, find the experience enriching and the personal networks and relationships that are formed endure far beyond the lifetime of the project. As evidence, at least 9 of the 13 academic and industry partners in YEASTCELL are currently collaborating with at least 1 other partner from the network in an ITN or another collaborative research project. Industry partners in YEASTCELL were especially positive and reported that they are more likely to hire a PhD graduate from an ITN than from another programme. Invariably, academic supervisors express a wish that they could have had such experience themselves.

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Authors' contributions

PB conceived the idea and provided input to and feedback on the manuscript. FD, LT and JM wrote the manuscript. All authors read and approved the final manuscript.

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