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## Why and how academics become interdisciplinary researchers early in their careers

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### ABSTRACT

The complexity of interdisciplinary research, including the time needed to understand multiple approaches and develop skills, within a university structure organised in disciplines, means that interdisciplinary research can be difficult for a developing researcher. However, early- and mid-career researchers (EMCRs) are key to the future of interdisciplinary research. This paper asks, 'Why and how do EMCRs become interdisciplinarians?' It draws on analysis of interviews supplemented by ethnographic observations from a research project exploring the development of interdisciplinary expertise in universities. This paper outlines six common intersecting career pathways through which EMCRs come to work across disciplines. The diverse and often ad hoc nature of interdisciplinary research careers implies that support systems, resources and training need to be adaptive and flexible.

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## Introduction

Interdisciplinary research has been identified as necessary for solving complex societal and environmental problems and a vital component of a successful research ecosystem (Arnold et al., 2021). This important role is acknowledged in governmental policies and university strategies (Graff, 2015) and has resulted in the establishment of programs, resources, and networks (e.g., Bammer, 2013) and multidisciplinary institutes and other structures to promote and support interdisciplinary research (Biancani et al., 2018; Leahey & Barringer, 2020).

Universities, however, lack a consistent approach to developing interdisciplinary research skills and knowledge, beyond very few interdisciplinary undergraduate degrees, isolated subjects, or one-off PhD programs (Lyll, 2019). In that context, it can be difficult to first attract PhD candidates to interdisciplinary research as a legitimate pathway, and then prepare for and maintain their interdisciplinary careers within the prevailing 'culture of disciplinarity' (Boden et al., 2011; Crossing Paths: Interdisciplinary Institutions, Careers, Education and Applications, 2016). In addition, extra time and effort needed to learn and integrate multiple disciplinary perspectives are accompanied

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by the understanding that grant and promotion panels tend not to rate interdisciplinary efforts favourably (Arnold et al., 2021; Bromham et al., 2016).

Despite these issues, early- and mid-career researchers (EMCRs) do pursue interdisciplinary research. Understanding why and how EMCRs become interdisciplinarians can help formalise and strengthen pathways and support institutions to foster interdisciplinary capacity. We use the term EMCR to refer to a range of researchers, from those completing their PhD through to 10 years after qualification, with the transition between early and mid-career at five years post-PhD completion. While the term covers researchers in different situations, with varying responsibilities and goals (e.g., PhD candidates in existing research projects as well as academics in full-time research and teaching roles, including lab leaders), in this paper, we focus on their research practices rather than other aspects of academic work. We use the term ‘interdisciplinary’ broadly to encompass interaction across two or more disciplines or knowledge fields, including collaboration with industry and community (Barry & Born, 2013). By ‘interdisciplinarian’, we mean a practitioner who often substantively works outside their home discipline and collaborates with people who do not have a shared disciplinary identity.

EMCRs encounter ‘countervailing institutional pressures’ (Graff, 2015, p. 2) against interdisciplinary work and are often advised or constrained to keep working within disciplinary research boundaries. This reinforces the traditional mode of employment in a university structured by disciplinary Schools and their teaching requirements. In addition, there is no consensus on the appropriate stage to engage in interdisciplinary work. Senior researchers tend to emphasise gaining disciplinary depth before diversifying (Ledford, 2015), while EMCRs themselves can be more optimistic about taking an early interdisciplinary path (Lyll, 2019).

Contrasting with the precarity of careers less aligned with a discipline, university strategies increasingly refer to the need to develop interdisciplinary programs and research (Graff, 2015), and mainstream research funding programs are progressively seeking interdisciplinarity in proposals (Australian Research Council, 2018; Canada Research Coordinating Committee, 2023).

In a traditionally organised university, students learn about opportunities through Schools and their disciplinary departments, aiming to become a chemist or a historian rather than inhabit a more interdisciplinary space. University Schools socialise their members during career transitions towards a discipline and its practices: interdisciplinary students and researchers can miss this sense of home-based support within a faculty or School (Gardner, 2011). Instead, they find novel networks and diverse mentors to help them navigate the university system and find work. In addition, the ‘academic hazards’ that EMCRs negotiate include lack of jobs, insecure employment, high workload and, for interdisciplinarians, additional administrative barriers, often arising from faculty-based structures and systems, and the undervaluation by the institution of aspects of their work otherwise valued by the researcher (Le, 2023). Interdisciplinary researchers can be ‘undermined’ by not conforming to normative disciplinary career paths (Müller & Kaltenbrunner, 2019). Thus, thriving within the university system can be especially complex for them.

With these considerable obstacles, why and how do academics become interdisciplinary researchers? Researchers have tended to only venture into the interdisciplinary sphere after first establishing themselves in their home discipline, using the freedom

that tenure and reputation confer (Lyall, 2019). In contrast, EMCRs, with little tenure or reputation, are increasingly starting at an early stage to be interdisciplinary. This can be through a range of pathways, including completing an interdisciplinary PhD or interdisciplinary undergraduate program (Legler et al., 2010); attachment to interdisciplinary projects, and through the efforts of institutes established to support interdisciplinary research (Hesjedal, 2022). The nature of interdisciplinary research suggests a strong intellectual curiosity and commitment to having a measurable impact on complex problems. Colleagues and the surrounding environment have also been shown to have a major influence on entering interdisciplinary research (Carayol & Thi, 2005).

In a study of academics who had graduated from a UK interdisciplinary PhD program, Lyall (2019) found one set of candidates based their entry to the program at least partly on an affinity for interdisciplinary approaches, via their research question or target profession, undergraduate or other experiences or guidance by supervisors. Another set of candidates strategically took the opportunity of a funded position. Lyall (2019) further divides reasons for pursuing interdisciplinary research into two camps, with some researchers spanning both. The reasons are presented as distinct profiles: the ‘problem solvers’ who focus on addressing real-world problems; and the ‘individual careers’ who focus on the role of interdisciplinarity in personal development and ‘broadening horizons’ (Lyall, 2019, pp. 24–25).

While some studies have focused on interdisciplinary programs aimed mainly at the preparation of PhD candidates (e.g., Boden et al., 2011; Gardner, 2011; Lyall, 2019), the pathways taken by EMCRs outside these programs into interdisciplinary research are under-explored. This paper addresses this by exploring why and how EMCRs who have not come through interdisciplinary PhD programs become interdisciplinary researchers. The research question is ‘Why and how do EMCRs become interdisciplinarians?’

To answer this question, we draw on data from a larger project exploring the development of interdisciplinary expertise in universities. We examined the personal resourcefulness and practices of people in two large interdisciplinary research centres (IRCs) who had not taken part in any specific interdisciplinary higher-degree research program and had come to interdisciplinary research through a mix of avenues, often relying on *ad hoc* support. In this paper, we focus on the reasons and practices that led them to interdisciplinary work. We then discuss the implications for how interdisciplinary EMCRs can be supported.

We first outline our study’s theoretical perspective and methodology. We then present the six pathways through which EMCRs come to work across disciplines, based on our analysis of the data. Finally, we discuss how EMCRs might be better supported in becoming interdisciplinarians.

## Context and method

### *Sites and data collection*

Data were gathered as part of a multi-year research project investigating the development of interdisciplinary expertise within IRCs, with human research ethics approval from The University of Sydney HREC, protocol number 2020/668. Semi-structured interviews

were used to investigate the transition pathways of interdisciplinary EMCRs. All interviewees gave written informed consent.

Twenty-seven EMCRs associated with two IRCs, in public health (IRC1) and advanced manufacturing (IRC2), in a large research-intensive Australian university were interviewed. All interviewees were involved in interdisciplinary projects or engaged in research-related initiatives and activities of IRCs, such as EMCR committees. The number of interviews helped us reach ‘meaning saturation’, or a stage in which we were able to be relatively sure to ‘fully *understand* all the issues raised’ (Hennink et al., 2017, p. 600).

The participants included, with some overlaps between fields: 10 PhD candidates, 7 ECRs, 10 MCRs; 8 in IRC1, 16 in IRC2 and 3 in both; 17 Female, 10 Male; 6 Humanities, Social Sciences and Arts, 10 Engineering, Design and Science, 11 Health and Medicine. Representative of the Australian university workforce, the interviewees included people born in Australia and overseas. All interviewees were given pseudonyms reflecting their perceived gender (Table 1).

Interviews lasted between 45 and 60 min. Informed by a practice theory perspective, the semi-structured interview questions were designed to probe key epistemic, material, and sociocultural dimensions of participants’ interdisciplinary activities and contexts (Knorr-Cetina, 1999; Nicolini, 2009). Questions also sought to elicit information about interviewees’ personal resourcefulness, with a focus on what enabled them to engage with interdisciplinary practices, including knowledge, skills, and attitudes (Markauskaite & Goodyear, 2017). Additional questions helped explore career paths and individuals’ experiences in interdisciplinary work, including enablers and

**Table 1.** Participant profiles.

Pseudonym	Primary discipline / area of research	IRC affiliation	Career stage	Gender
Evie	Microbiology, immunology	IRC1	PhD	F
Louise	Nutrition and dietetics	IRC1	PhD	F
Maggie	Public health	IRC1	PhD	F
Luke	Neuropathology	IRC1	PhD	M
Ava	Chemistry	IRC2	PhD	F
Mary	Physics	IRC2	PhD	F
Elijah	Design	IRC2	PhD	M
Henry	Business	IRC2	PhD	M
Peter	Physics, chemistry	IRC2	PhD	M
Robert	Quantum physics	IRC2	PhD	M
Carina	Neuroscience, molecular biology, oncology	IRC1	Early	F
Elle	Sports science	IRC1	Early	F
Mia	Chronic disease, healthy ageing	IRC1&2	Early	F
Jason	Nanomedicine	IRC1&2	Early	M
Anna	Business	IRC2	Early	F
Emily	Philosophy, ethics	IRC2	Early	F
William	Business	IRC2	Early	M
Naomi	Chemistry, biological sensors	IRC2	Early/Mid	F
Diane	Biology	IRC1	Mid	F
Kate	Nutrition	IRC1	Mid	F
David	Psychology	IRC1&2	Mid	M
Carol	Pharmacy	IRC2	Mid	F
Aria	Chemical engineering, bioengineering	IRC2	Mid	F
Elena	Architecture, materials design	IRC2	Mid	F
Sophy	Media and sound studies	IRC2	Mid	F
Jack	Musician, musical composition	IRC2	Mid	M
Thomas	Biological design	IRC2	Mid	M

barriers. The answers incorporated personal narratives and predominantly focused on research.

### Data analysis

Interview transcripts were analysed with NVivo software using an abductive analytical approach (Timmermans, 2022), with initial codes informed by the theoretical frameworks of personal resourcefulness and practice theory (Kemmis, 2022; Knorr-Cetina, 1999; Markauskaite & Goodyear, 2017). The analysis was also guided by the concept of dispositions, which includes an *inclination* towards particular areas or goals, influenced by, e.g., habit, motivation, or values; a *sensitivity* to or recognition of opportunities; and *abilities* to take action (Perkins et al., 1993). Simultaneously, we applied a set of broad thematic codes that described common dimensions of practice and its environment: cognitive-epistemic, related to knowledge creation and knowledge work; material-economic, including physical and digital infrastructure and systems of administration, and funding; and social-cultural, which includes relationships and cultural practices within the university and its bodies (Kemmis, 2022; Markauskaite & Goodyear, 2017). As we applied these codes, we created sub-codes and further high-level categories as analytic memos (Saldaña, 2016) to produce inductive meaning. These included an expanded set of codes in taxonomic trees related to practice and its environment (e.g., research funding, publishing, administration, networks, mentorship, and other connections and collaborations) and a set of codes that organised references to personal careers (e.g., academic and personal background, plans, aspirations, progress, and obstacles).

After coding each transcript, we compared EMCR interview excerpts grouped together under relevant codes. Using a comparison of commonalities and differences between coded excerpts from interviews, we established common themes that characterised why and how EMCRs came to be interdisciplinary, which we organised into descriptions of pathways. We reviewed initial pathway themes for internal cohesion to ensure each was discrete and had a distinct primary focus, resulting in the combination of themes that overlapped and the splitting of a new theme from one that contained several foci. This included ‘zooming in’ to bring to the fore individual interdisciplinary resourcefulness, activities, and career pathways, and then ‘zooming out’ by ‘finding the associations between practices’ and identifying the effects of practices in patterns from local to global (Nicolini, 2009, p. 1408).

The trustworthiness (Korstjens & Moser, 2018) of the findings is supported by investigator confirmation through detailed iterative analysis that reinforced initial broad themes identified by the third author with expanded, detailed coding by the first author. The three authors maintained a prolonged engagement in the research, having for three years conducted interviews and observed activities involving interdisciplinary EMCRs, and have co-constructed the findings through critical discussion.

### Findings

Our analysis of interviewees’ narratives revealed six pathways to establishing a career as an interdisciplinary researcher (Table 2). There tended to be a main pathway for each person, but some individuals took more than one. Each pathway had a distinct

**Table 2.** Interdisciplinary career pathways and practices.

Pathway	Disposition	Primary focus	Dominant dimension of practice
1. One Person Band	Personal interests that prompt the development of knowledge and skills in multiple disciplinary fields	Interests	Cognitive-epistemic
2. Niche Providers	Specialised capabilities that lead to working on projects outside the initial disciplinary field	Capabilities	Cognitive-epistemic
3. Problem Chasers	Solving an important problem that requires interdisciplinary approaches	Problem	Cognitive-epistemic
4. Facilitators and Connectors	Recognising the importance of facilitating interactions across disciplines in collaborative projects	Process	Social-cultural
5. Teammates	Open to interdisciplinary opportunities through socialisation	Collaborations	Social-cultural
6. Employment Seekers	Personal practical circumstances draw researchers into projects and associated teams	Necessity	Material-economic

disposition, primary focus, and dominant dimension of practice. In what follows, pathways are illustrated by quotes and stories that highlight the reasons (why) and practices (how) that characterise them.

### 1. One person band

EMCRs who came to interdisciplinarity predominantly through the One Person Band pathway tended to have a wide-ranging curiosity that led them to pursue more than one discipline. They described taking up new methods and skills from other disciplines to bring together a bricolage of personal resources to their work, through formal and informal means, including industry experience.

As examples of EMCRs undertaking formal studies beyond one discipline, Peter and Naomi had several majors, Evie studied ‘random units’ such as psychology and medical ethics, Robert completed a double degree, Henry and Emily took degrees in different disciplines, and Sophy studied US liberal arts that encourage interdisciplinary approaches.

A personal drive was evident. For instance, Mia, with a molecular biology background, chose to work with a colleague to expand her surgical techniques, moving to vascular biology, and then to materials science. Carol was interested in learning varied techniques and became self-sufficient with few collaborators as, ‘I can do everything from chemistry all the way to animal studies.’ Elijah, a PhD candidate in design, actively looks for ‘fruitful new areas’ for research specialisation. He uses conversations with researchers from other disciplines to look for ‘those almost combinatorial moments’ to find ‘troughs of knowledge ... that you can do a pile of work in.’

Some EMCRs brought skills from other areas to their work. As a case in point, working in audiovisual support helped Robert, a PhD candidate in quantum physics, with an understanding of the ‘poles and wires stuff ... how to use Telnet ... or how to set up a small network’, which he noted could be as important as mastering theory.

There is an eclectic, curious nature to One Person Banders, who appreciate ‘time to learn’ (Mia) and are ‘part of a generation where it’s like, eff around and find out’ (Robert). Although they experienced drawbacks, such as frustrating curriculum overlaps, and tensions between learning independently and needing guidance against wasting time, personal interest was a strong motivator in developing knowledge and skills in multiple fields.

## 2. Niche providers

Niche Providers are EMCRs who came to interdisciplinarity having developed specialised skills that are in demand across contexts. Valued niche skills and knowledge could come from close or distant disciplines. For example, business researchers worked with STEM teams because of their expertise in research commercialisation (Henry, Robert, Anna).

EMCRs did not necessarily seek interdisciplinary projects, but niche skills meant that they were sought after to work on projects outside of their initial discipline. This was particularly the case for EMCRs who mastered complex procedures or operated complicated, expensive equipment. For example, Jason joined a project as a postdoctoral researcher partly due to his microscopy techniques, but as the only postdoctoral researcher on the team, his duties expanded into other areas, including physics. Another example was Diane who was in demand for a specialised surgical procedure.

Sometimes, though, the niche skills relegated the EMCR on the Niche Provider path to a subordinate role with few personal benefits. For example, Peter, a PhD candidate, was asked to run analyses and tests without ‘much idea of the broader picture’ and realised a particular contribution only after reading a published paper that included it. People with niche skills were in danger of simply fulfilling a service, but their work also exposed them to a range of further research and networking opportunities. If Diane was not deeply involved in all projects, they provided contacts for more interesting, ongoing work; Jason’s niche skills created opportunities for expanded research and associated success.

## 3. Problem chasers

Some EMCRs clearly showed dedication to exploring and solving problems that were absorbing, complex and inherently interdisciplinary. This included research into applied or translational problems with multiple factors that often involved human behaviour.

The EMCRs who were on the Problem Chaser path talked animatedly about research goals. Maggie investigated ‘mental wellbeing, burnout as well as the lifestyle and chronic disease risk.’ Emily trained others in genetic counselling, requiring STEM and social science knowledge, and investigated genetic screening ethics. Louise and Kate researched diet for older adults, which involved studying a range of factors in peoples’ lives with a microbiologist, immunologist, and exercise physiologist.

Problems could materialise from early research experiences. Naomi encountered limitations in analysis techniques for her PhD that she subsequently aimed to improve, moving into new fields to do so. Evie wanted to find ‘novel therapies to tackle antibiotic resistance.’ While this primarily involved basic lab research, she also attended clinics to observe patients’ experiences of therapies.

The attraction for many EMCRs was real-world problems and impact. Naomi enjoyed organic over materials chemistry because of its relationship to ‘medicines or diagnostics.’ Several EMCRs’ work on commercialisation of research involved multi-disciplinary research partners. They noted that being focused on applied research required personal

versatility in a range of methods and fields, as tasks requiring knowledge of the science could not be delegated (Carol, Jason, Mary).

Problem Chasers tended to value work within a wider, applied context for achieving impact. This did not always correspond with conventional measures of research excellence (e.g., publications) or academic advancement.

#### **4. Facilitators and connectors**

EMCRs on the Facilitator and Connector pathway recognised a need for enablers of interdisciplinary work through leadership, facilitation, and knowledge integration. This pathway was not necessarily an entry point but incorporates interdisciplinary practices described by EMCRs.

As a Facilitator and Connector, Elijah was ‘often the person who’s synthesising different domains together, ... to ameliorate the distinctions between [two approaches] ... and work with them to produce a third thing.’ Henry saw a need for a large conversation to ‘bridge’ what happens in social science and STEM ‘because those two worlds at least to me seem almost completely disconnected.’

Connecting and leading the right people were identified by multiple EMCRs as necessary for successful interdisciplinary projects. For example, Kate wanted more effective collaboration between disciplines to improve the notoriously low success rate of clinical trials. Mia acknowledged the need for ‘leadership to put everyone in the same direction.’ EMCRs in this role did not generally shy away from the opportunity. Jason valued learning to be an interdisciplinary leader, starting in a project in which he did the ‘heavy lifting’ to be the ‘go-between’ for collaborating experts. David said, ‘I do like making connections, putting people together and helping form collaborations’ and Peter felt happy with his ability to do this as well.

Without wider acceptance of the need for facilitation and integration skills, it was sometimes difficult for EMCRs wishing to engage on the Facilitators and Connectors path to secure such a role. For instance, Naomi was aware of the importance of group cohesion of having someone translate and connect the different disciplinary languages, while also noting that ‘there are people who don’t realise that [you need to use different language]. They either don’t realise it or don’t care enough.’

#### **5. Teammates**

The ways in which team and wider networks’ members collaborated and approached problems acted as a template and springboard for new researchers open to exploring interdisciplinary problems under the guidance of peers and mentors.

For STEM PhD candidates, work tended to be defined through labs and projects, attenuated by exposure to colleagues’ interdisciplinary activities. Some early career researchers identified with the goals of the team and were content to flexibly explore interests and opportunities that came from that association: ‘right now I feel like I’m sort of collaborating or working interdisciplinary from the bottom’ (Elle).

The EMCRs on the Teammates path often expanded and honed their research skillset through collaborations. Some EMCRs were members of a wide network of researchers or collaboratives that provided them with connections (Aria), expanded horizons (Carina)

and other opportunities. Like other PhD candidates, Ava, a chemist, met regularly with her research group and was routinely required to present to other research groups: one presentation garnered methodological advice from physicists. Until given the opportunity to connect, Kate ‘didn’t know a mathematician could help me.’ After taking double majors, Peter chose the discipline for his PhD partly on that department’s open-ness to cross-group collaboration.

Half of the EMCRs interviewed explicitly mentioned mentors as key influences on research topics and approaches to research and collaboration. Mentors not only acted as connectors to networks, expanders of horizons and providers of employment opportunities, they also provided encouragement and support for learning new techniques from different fields. Some EMCRs had mentors from different disciplines. Ava’s PhD supervisors came from science and engineering. Jason, lacking interdisciplinary mentoring during his PhD, as a postdoc gathered 15 multi-field senior mentors.

The availability of and interaction with mentors and other team members relied on serendipity or the EMCR seeking them out and articulating goals. EMCRs did not necessarily encounter interdisciplinary practices as PhD candidates.

## **6. Employment seekers**

For some EMCRs, interdisciplinarity stemmed from finding employment. Some moved from their original research area or expanded into multiple areas by obtaining a position because it fitted with family, financial or other commitments and priorities. Some found limited choices, because of competition for positions, institutional capacity in their target city, range of funded projects and their network of mentors and peers. Available roles tended to require mastering new skills and/or relied on the researcher’s niche skills.

For example, Jason changed focus away from his PhD research and had to learn a range of skills when joining an interdisciplinary project as the sole postdoc and was less involved in basic research. The position has, however, helped him move towards leadership and the project has produced a patent and ranked publications. Diane moved from her original research focus to one only tangentially related when personal circumstances required her to remain in a particular city rather than pursue a postdoctoral position elsewhere. Mia transitioned from molecular biologist to vascular biologist, following a supervisor’s specialisation, and then through the work moved into engineering.

Sometimes, secure employment was an enabler for interdisciplinary research aspirations. For example, Anna was only able to consider an interdisciplinary project in IRC2 once she was in a continuing academic position.

The employment route into interdisciplinary research required flexibility and adaptation but was not necessarily counter to the agency of the researchers, who made decisions based on a range of criteria including their interests.

## **Research grants**

The perceived availability of grants—whether internal or external, small or large—for interdisciplinary research was a keen topic among EMCRs. Some had secured funding,

while many were still seeking it. They saw value in small university internal grants, ‘to help us get these bigger external funds’ (David). IRCs provided seed funding—Elena happily received a medium-sized grant from IRC2 that allowed her some research freedom. One researcher intended to stay in a particular School because of generous funding and support for research. In other words, interdisciplinary EMCRs have similar concerns to other EMCRs. However, on top of the usual lack of experience and tacit knowledge that hampers applications, the complexity of interdisciplinary projects and the opacity of evaluation processes increased uncertainty.

Several EMCRs felt that funding programs were not receptive to applications for interdisciplinary research. One interdisciplinary application by David’s team received a scathing review suggesting that it take a completely different, disciplinary, approach. Thomas had been chasing funding for an interdisciplinary communications technology design project for years, citing difficulty in communicating research beyond reviewers’ usual domains. Jason believed his interdisciplinary team may have reached an unspoken quota limit after several initial grants.

Perceived attainability of grants and the probability of success influenced how EMCRs expended their efforts, either towards interdisciplinary projects or greener pastures elsewhere.

## Discussion and implications

For many EMCRs, their way to interdisciplinarity was shaped by multiple reasons and associated practices that were not mutually exclusive, and involved multiple, intertwined pathways. Mia, who focused on the problem of ageing and chronic disease, independently expanded her skills and fields and was greatly influenced by her multi-disciplinary mentors. Her career weaved Problem Chaser, One Person Band and Teammate stories and was shaped by cognitive-epistemic and social-cultural considerations. Diane chased available employment when unable to move cities and applied for a role in a local large interdisciplinary project. Subsequently, she contributed to its experimental design and data collection to, for example, ensure gender parity in research subjects, and was writing a grant application to extend the project. Moving from seeking employment to chasing problems, her research career was initially shaped by material-economic considerations. Like that of Carol, it has not followed normal routes and has lagged behind contemporaries in promotion, if still affording levels of epistemic agency doing interesting work.

Others drop in and out of these pathways to return to disciplinary research. Some straddle several paths simultaneously. For example, some EMCRs were Niche Providers and Facilitators and Connectors as they used their specialised expertise to facilitate interdisciplinary teamwork. This is well illustrated by Thomas, a designer, who used his expertise in design thinking to identify wicked problems in ‘that tame [if often still complex] space’ towards which scientists can aim their research. William, in business, also used design thinking as a ‘wingman’ to a team of STEM researchers exploring commercialisation.

It should be noted, though, that there is a limit to what should be asked of junior team members. Lindvig (2018) found that principal investigators unfairly expected PhD candidates to be the connectors between disciplines, and cautioned that PhD candidates, often with a niche skill connecting them to other teams, should not be over-burdened.

Notwithstanding, EMCRs in the study expressed interest in connecting, facilitating, and leading.

It is reasonable to assert that for a sustainable interdisciplinary research career (i.e., not only starting but continuing with interdisciplinarity), there is a need for multiple pathways and greater support systems, including conducive employment frameworks, resources, and training to address the serendipitous and often *ad hoc* nature of interdisciplinary research. Interdisciplinary researchers need but do not always experience supportive and hospitable environments. Opportunities to network outside a home School will assist researchers in looking for gaps and intersections with other disciplines leading to new research foci. Further, as students, they might experience barriers and overlaps in multidisciplinary studies, double majors, and double degrees. Purposely designed programs in interdisciplinary areas such as systems biology (Cvijovic et al., 2016) or nanotechnology (Goonewardene et al., 2016) can mitigate this. By engaging with potential interdisciplinary PhD candidates beyond Schools, such as through undergraduate interdisciplinary projects addressing real-world problems (Legler et al., 2010; Raicu & Furst, 2009), interdisciplinary options become more visible. Removing the serious administrative barriers to PhD supervision from multiple faculties is another useful measure.

While individual agency is key, personal development and career support, flexibly available and adaptive to individuals, are also needed for each of the pathways. As such, for those predominantly **One Person Band**, EMCRs could be assigned a mentor to follow their progress, provide relevant guidance and connections to academics and technicians as conduits to relevant knowledge, techniques, facilities, and instruments, as well as to help them overcome occasional unproductive side tracks or pressures.

Those engaging on the **Niche Provider** path could benefit from consultation on career planning and research goals that leverage their skills (e.g., first authorship on a paper, negotiating recognition for contributions, and how to secure other tangible outcomes relevant to professional development). Niche seeking is an identified mechanism for coping with disciplinary demands in interdisciplinary research and can help the academic justify that work to their department (Woiwode & Froese, 2021). The niche provider from a more distant discipline will rely on team members' open-mindedness towards their input on research design or data collection. They may be junior to those to whom they provide advice, and so prospectively benefit from developing relationship management and facilitator skills.

**Problem Chasers** value the freedom to work with others to solve a challenge or question that they perceive as important and that can be passionately pursued. The imperative of the problem dictates preferred collaborators and activities, both within and outside the university. A study of interdisciplinary output found that it is increased by 'having published at least one paper with a researcher employed in industry' (Carayol & Thi, 2005, p. 76). Specifically for Problem Chasers, but also for other interdisciplinary researchers, flexible access to resources (e.g., funding, equipment, and connections) and removal of administrative barriers (e.g., inter-School funding and collaboration) are useful. Funded project support that includes 'permission' to approach senior researchers is also a feature of helping EMCRs towards leadership in research (Gibson et al., 2019).

The **Connector and Facilitator** can feel challenged by the complexity of a project and 'disconnected from faculty and peers, having to span boundaries between areas,

departments, and knowledge bases' (Gardner, 2011, p. 88), and is deserving of a community of practice. They could benefit from networking opportunities with others in similar roles and recognition for their contributions. This might include specifying project roles in design and facilitation. This might also include training in interdisciplinary knowledge integration processes (Larson et al., 2011), Integration and Implementation Sciences (Bammer, 2013), or design thinking. Being clear on how research is conceptualised and coordinated across disciplines is important for epistemic and practical considerations (Leigh & Brown, 2021).

While EMCRs on the *Teammates* path tend to be surrounded by diverse practices and potential mentors and connectors, they could benefit from introductions to researchers in other disciplines and from regular seminars, networking events and being shown the bigger picture beyond their role. The networks available in and through both closely collaborative and more loosely organised teams can influence researchers by bringing them 'closer to burgeoning research trends' (Heffernan, 2021, p. 991). Physical spaces that allow casual observation and conversations across teams assist EMCR development and peer support, which has been recognised as extremely valuable to developing academics, especially in implementation science (Dickson et al., 2021).

Heterogeneity in teams is linked to creativity (Pennington, 2016) and the interdisciplinarity of team members (Carayol & Thi, 2005). The size of a lab can influence interdisciplinarity: in larger labs, researchers tend to stay within their specialisation while smaller labs require researchers to touch upon multiple research areas (Carayol & Thi, 2005). In addition, mentoring can have varying usefulness (Boeren et al., 2015). Structured support for EMCRs, such as training in developing interdisciplinary perspectives and skills, can supplement teammates.

For *Employment Seekers*, networking opportunities are key to gaining employment, although access to strategic networks can be unequal, e.g., between genders (Heffernan, 2021), so equitable inclusion is a consideration. If EMCRs are lucky, they land in an interesting field for which they have or find an affinity, and which affords career agency and progress. As for niche providers, employment seekers may benefit from targeted mentoring and the leeway to pursue an aspect of personal interest.

More stable employment and research funding can assist EMCRs in finding the work that is important to them, regardless of their pathway into interdisciplinary research. Interdisciplinary EMCRs will particularly benefit from a career path 'in which uncertainties are minimized and options are maximized' (Le, 2023, p. 11). A ceiling for ongoing employment for interdisciplinary researchers has been identified as the 'perpetual research fellow problem' in which lack of disciplinary teaching roles (the usual route to promotion) consigns many researchers to remain at one level of employment (Lyall, 2019, p. 114).

In pursuing research grants, EMCRs need support in preparing and writing grant applications, with guidance on the complexities of including multiple disciplines, and time to integrate those aspects. How to write to appeal to disciplinary evaluators of an interdisciplinary project is one such skill. Although grant programs specify interdisciplinarity, it is still difficult to write an application to appeal to diverse reviewers and part of the responsibility lies with the funders to ensure appropriate evaluation (Lyall, 2019). Communications through inclusive networks can inform EMCRs about access to interdisciplinary opportunities, which they may not hear about through a disciplinary

department (Gardner, 2011). An interdisciplinary project, from grant application onwards, will require skills and professional development in, e.g., consultative leadership, project management and cross-disciplinary knowledge integration: the skills of the Connector and Facilitator. University and IRC programs targeting interdisciplinary project development across Schools are a useful step.

## Conclusion

Our study shows that some EMCRs craft or choose their way while others ‘fall’ into interdisciplinary research. It also briefly highlights the barriers, in particular how reward and support systems are not commensurate with the university’s stated high-level commitments to interdisciplinary research. Cultures of exclusion can exist around disciplines, which, coupled with the power imbalances experienced by EMCRs, are antithetical to the transparent, open, and supportive environment needed for interdisciplinary work and learning. Responsibility for the practices within cultures and for changing them lies with those who enact those practices (Kemmis, 2022): the institution (e.g., expanded promotion criteria); teams (e.g., flat structures inviting equal contributions); and individuals (e.g., active open listening).

While interviewees faced similar barriers as do disciplinary researchers, there was a distinctive lack of support for interdisciplinary research, especially for EMCRs, which required strong individual agency from those choosing to be interdisciplinarians. An unclear way forward, isolation, and the prospect of less advancement acted as barriers to embarking on interdisciplinary research pathways. We have suggested ways to assist academics becoming interdisciplinarians, but more is needed to ensure sustainable careers and clear pathways. This could include recognising research excellence that comes from interdisciplinary work, such as: small, often key, contributions to team papers; impacts on policy; or translation and commercialisation.

We are mindful that the findings represent the views of a small group of EMCRs from one university and engaged in STEM-centric IRCs—only six interviewees from social sciences and humanities. Accordingly, we do not claim the findings are exhaustive but illustrate possible pathways into interdisciplinarity, as reflected in the data.

No matter how researchers come to be interdisciplinarians, a long-term interdisciplinary career will require a personal (cognitive-epistemic) affinity and passion for solving interdisciplinary research problems and systemic support for that career that involves social-cultural and economic-material aspects at multiple levels. Universities, research institutes, teams, and individuals, therefore, need to deliberately, daily practice and produce effective structures and support for interdisciplinary EMCRs (Lyll, 2019) within a culture of support, recognition, and reward for interdisciplinary research.

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## References

- Arnold, A., Cafer, A., Green, J., Haines, S., Mann, G., & Rosenthal, M. (2021). Perspective: Promoting and fostering multidisciplinary research in universities. *Research Policy*, *50*(9), 104334. <https://doi.org/10.1016/j.respol.2021.104334>
- Australian Research Council. (2018). *ARC statement of support for interdisciplinary research*. Australian Research Council. <https://www.arc.gov.au/sites/default/files/2022-06/ARC%20Statement%20of%20Support%20For%20Interdisciplinary%20Research.pdf>.
- Bammer, G. (2013). *Disciplining interdisciplinarity: Integration and implementation sciences for researching complex real-world problems*. ANU Press.
- Barry, A., & Born, G. (Eds.) (2013). *Interdisciplinarity: Reconfigurations of the social and natural sciences* (pp. 1-56). Taylor & Francis Group.
- Biancani, S., Dahlander, L., McFarland, D. A., & Smith, S. (2018). Superstars in the making? The broad effects of interdisciplinary centers. *Research Policy*, *47*(3), 543–557. <https://doi.org/10.1016/j.respol.2018.01.014>
- Boden, D., Borrego, M., & Newswander, L. K. (2011). Student socialization in interdisciplinary doctoral education. *Higher Education*, *62*(6), 741–755. <https://doi.org/10.1007/s10734-011-9415-1>
- Boeren, E., Lokhtina-Antoniou, I., Sakurai, Y., Herman, C., & McAlpine, L. (2015). Mentoring: A review of early career researcher studies. *Frontline Learning Research*, *3*(3), 68–80. <https://doi.org/10.14786/flr.v3i3.186>
- Bromham, L., Dinnage, R., & Hua, X. (2016). Interdisciplinary research has consistently lower funding success. *Nature*, *534*(7609), 684–693. <https://doi.org/10.1038/nature18315>
- Canada Research Coordinating Committee. (2023, April 19). *Government of Canada invests in high-risk, high-reward interdisciplinary research to support world-leading innovation* [News releases]. <https://www.canada.ca/en/research-coordinating-committee/news/2023/04/government-of-canada-invests-in-high-risk-high-reward-interdisciplinary-research-to-support-world-leading-innovation.html>.
- Carayol, N., & Thi, T. U. N. (2005). Why do academic scientists engage in interdisciplinary research? *Research Evaluation*, *14*(1), 70–79. <https://doi.org/10.3152/147154405781776355>
- Crossing Paths: Interdisciplinary institutions, careers, education and applications. (2016). The British Academy. <https://www.thebritishacademy.ac.uk/documents/213/crossing-paths.pdf>.
- Cvijovic, M., Höfer, T., Aćimović, J., Alberghina, L., Almaas, E., Besozzi, D., Blomberg, A., Bretschneider, T., Cascante, M., Collin, O., de Atauri, P., Depner, C., Dickinson, R., Dobrzynski, M., Fleck, C., Garcia-Ojalvo, J., Gonze, D., Hahn, J., Hess, H. M.,...Hohmann, S. (2016). Strategies for structuring interdisciplinary education in systems biology: An European perspective. *Npj Systems Biology and Applications*, *2*(1), 1–7. Article 1. <https://doi.org/10.1038/npjbsa.2016.11>
- Dickson, K. S., Glass, J. E., Barnett, M. L., Graham, A. K., Powell, B. J., & Stadnick, N. A. (2021). Value of peer mentoring for early career professional, research, and personal development: A case study of implementation scientists. *Journal of Clinical and Translational Science*, *5*(1), e112. <https://doi.org/10.1017/cts.2021.776>
- Gardner, S. K. (2011). A jack-of-all trades and a master of some of them?: Successful students in interdisciplinary PhD programs. *Issues in Integrative Studies*, *29*, 84–117. [https://interdisciplinystudies.org/wp-content/issues/vol29\\_2011/06\\_Vol\\_29\\_pp\\_84\\_117.pdf](https://interdisciplinystudies.org/wp-content/issues/vol29_2011/06_Vol_29_pp_84_117.pdf).
- Gibson, C., Stutchbury, T., Ikutegbe, V., & Michielin, N. (2019). Challenge-led interdisciplinary research in practice: Program design, early career research, and a dialogic approach to building unlikely collaborations. *Research Evaluation*, *28*(1), 51–62. <https://doi.org/10.1093/reseval/rvy039>

- Goonewardene, A. U., Offutt, C. A., Whiting, J., & Woodhouse, D. (2016). An interdisciplinary approach to success for underrepresented students in STEM. *Journal of College Science Teaching*, 45(4), 9. [https://doi.org/10.2505/4/jcst16\\_045\\_04\\_59](https://doi.org/10.2505/4/jcst16_045_04_59)
- Graff, H. J. (2015). *Undisciplining knowledge: Interdisciplinarity in the twentieth century*. Johns Hopkins University Press.
- Heffernan, T. (2021). Academic networks and career trajectory: ‘There’s no career in academia without networks’. *Higher Education Research & Development*, 40(5), 981–994. <https://doi.org/10.1080/07294360.2020.1799948>
- Hennink, M. M., Kaiser, B. N., & Marconi, V. C. (2017). Code saturation versus meaning saturation: How many interviews are enough? *Qualitative Health Research*, 27(4), 591–608. <https://doi.org/10.1177/1049732316665344>
- Hesjedal, M. B. (2022). Socializing scientists into interdisciplinarity by placemaking in a multi-sited research center. *Science, Technology, & Human Values*, 48(5), 1110–1137. <https://doi.org/10.1177/01622439221100867>
- Kemmis, S. (2022). *Transforming practices: Changing the world with the theory of practice architectures*. Springer Nature.
- Knorr-Cetina, K. (1999). *Epistemic cultures: How the sciences make knowledge*. Harvard University Press.
- Korstjens, I., & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing. *European Journal of General Practice*, 24(1), 120–124. <https://doi.org/10.1080/13814788.2017.1375092>
- Larson, E. L., Landers, T. F., & Begg, M. D. (2011). Building interdisciplinary research models: A didactic course to prepare interdisciplinary scholars and faculty. *Clinical and Translational Science*, 4(1), 38–41. <https://doi.org/10.1111/j.1752-8062.2010.00258.x>
- Le, A. T. (2023). To be or not to be (in academia)? ‘Inward calling’ and ‘academic hazards’ in aspiring academics’ career prospects in Australia. *Higher Education Research & Development*, 42(4), 874–887. <https://doi.org/10.1080/07294360.2022.2123901>
- Leahey, E., & Barringer, S. N. (2020). Universities’ commitment to interdisciplinary research: To what end? *Research Policy*, 49(2), 103910. <https://doi.org/10.1016/j.respol.2019.103910>
- Ledford, H. (2015). How to solve the world’s biggest problems. *Nature*, 525(7569), 308–311. <https://doi.org/10.1038/525308a>
- Legler, J., Roback, P., Ziegler-Graham, K., Scott, J., Lane-Getaz, S., & Richey, M. (2010). A model for an interdisciplinary undergraduate research program. *The American Statistician*, 64(1), 59–69. <https://doi.org/10.1198/tast.2010.09198>
- Leigh, J., & Brown, N. (2021). Researcher experiences in practice-based interdisciplinary research. *Research Evaluation*, 30(4), 421–430. <https://doi.org/10.1093/reseval/rvab018>
- Lindvig, K. (2018). The implied PhD student of interdisciplinary research projects within mono-disciplinary structures. *Higher Education Research & Development*, 37(6), 1171–1185. <https://doi.org/10.1080/07294360.2018.1474343>
- Lyall, C.. (2019). *Being an interdisciplinary academic: How institutions shape university careers*. Palgrave Pivot Cham. <https://doi.org/10.1007/978-3-030-18659-3>.
- Markauskaite, L., & Goodyear, P. (2017). *Epistemic fluency and professional education: Innovation, knowledgeable action and actionable knowledge*. Springer.
- Müller, R., & Kaltenbrunner, W. (2019). Re-disciplining academic careers? Interdisciplinary practice and career development in a Swedish environmental sciences research center. *Minerva: A Review of Science, Learning and Policy*, 57(4), 479–499. <https://doi.org/10.1007/s11024-019-09373-6>
- Nicolini, D. (2009). Zooming in and out: Studying practices by switching theoretical lenses and trailing connections. *Organization Studies*, 30(12), 1391–1418. <https://doi.org/10.1177/0170840609349875>
- Pennington, D. (2016). A conceptual model for knowledge integration in interdisciplinary teams: Orchestrating individual learning and group processes. *Journal of Environmental Studies and Sciences*, 6(2), 300–312. <https://doi.org/10.1007/s13412-015-0354-5>
- Perkins, D. N., Jay, E., & Tishman, S. (1993). Beyond abilities: A dispositional theory of thinking. *Merrill-Palmer Quarterly*, 39(1), 1–21.

- Raicu, D. S., & Furst, J. D. (2009). Enhancing undergraduate education: A REU model for interdisciplinary research. *ACM SIGCSE Bulletin*, *41*(1), 468–472. <https://doi.org/10.1145/1539024.1509027>
- Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). SAGE.
- Timmermans, S. (2022). *Data analysis in qualitative research: Theorizing with abductive analysis*. The University of Chicago Press.
- Woiwode, H., & Froese, A. (2021). Two hearts beating in a research centers' chest: How scholars in interdisciplinary research settings cope with monodisciplinary deep structures. *Studies in Higher Education*, *46*(11), 2230–2244. <https://doi.org/10.1080/03075079.2020.1716321>