Doing creative research

A good practice guide for postgraduate researchers in STEM disciplines
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About Vitae

Vitae is supported by Research Councils UK (RCUK) and managed by CRAC: The Careers Development Organisation. Vitae’s vision is for the UK to be world class in supporting the personal, professional and career development of researchers.

To achieve our vision we have four aims:
• Building human capital by influencing the development and implementation of effective policy relating to researcher development
• Enhancing higher education provision to train and develop researchers
• Empowering researchers to make an impact in their careers
• Evidencing the impact of professional and career development support for researchers

Vitae’s work with higher education institutions

Vitae works with UK higher education institutions (HEIs) to embed professional and career development in the research environment. Vitae plays a major role in innovating, sharing practice and enhancing the capability of the higher education sector to provide world-class professional development and training of researchers. We do this both through national projects and Hub activities.

The programme develops resources for use by trainers and others working with researchers, and provides opportunities for HEIs to share information and practice; develop ideas and approaches; and work collaboratively.
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Developing creativity is vital both to the success of your PhD and to your ongoing development as a researcher. It’s important because:

- It underpins the original contribution your PhD needs to make to your chosen field of research
- It enhances all of the other research skills you develop during your PhD
- It generates the original ideas which lead to new discoveries and inventions and is, therefore, absolutely central to innovation

Therefore, it is crucial for you, as a postgraduate researcher in the STEM disciplines (science, technology, engineering and mathematics), to develop creativity as you build your portfolio of research skills.

Despite the centrality of creativity to all STEM research, there is very little available information about what it is, or how to incorporate it into your PhD. This is why the Graduate School and the Postdoc Development Centre at Imperial College London have collaborated on a research project looking at how postgraduate researchers (PGR) across the STEM disciplines can develop and use creativity in their work.

The aim of this guide is to communicate the key findings of the project, and to provide you with up to date information, tools and techniques on how to make your PhD a more creative process. So, whether you are an astrophysicist or an immunologist, a molecular biologist or a pure mathematician, this guide can help you.
What is creativity?

People tend to associate creativity primarily with the arts, but it is also core to scientific and technological endeavour. So what is creativity?

Creativity is understood and described in many different ways depending on the context. In the STEM research environment, creativity is usually defined as:
- The development of ideas and products that are original and useful
- The examination and/or combination of existing facts, ideas and theories in original and useful ways

STEM researchers use creativity to develop and explore new problems and re-examine, re-articulate or solve existing ones in novel ways.

Deciding what is and isn’t creative is not straightforward in practice. For example, who chooses whether an idea is useful, or who it might be useful to? How can we know that an idea, invention or discovery might not be useful in future? These questions illustrate the fact that creativity is a nebulous concept, and any definition (including ours) is context sensitive.

Despite being tricky to pin down, it’s often argued that ‘you know creativity when you see it.’ The box below outlines the behaviours demonstrated by PGRs who are developing creativity and using it in their research.

PART ONE
Creativity

The Research Development Framework (RDF) names creativity as one of the intellectual abilities core to the development of excellent researchers.

Behaviour of a creative researcher:
- Develops new ways of working; has novel ideas and realises their potential
- Identifies new trends; creates new opportunities
- Develops convincing and persuasive arguments to defend research
- Takes intellectual risks; challenges the status quo

Further information about the RDF can be found at:
→ www.vitae.ac.uk/rdf
Who is creative?

Until recently, creativity was seen as a rare talent which a person either possessed or they didn’t. Creative scientists were identified by their contributions, which were thought to be exceptionally novel and significant, and people tried to discover the characteristics that set them apart from other, less creative people.

Today, it is widely understood that every researcher has the potential to develop and use creativity, although an individual’s skills, knowledge and abilities will influence the ways in which their creativity is expressed. The results of their creative endeavour will also vary.

In the world of science and technology, creativity is no longer simply a matter of individual geniuses making paradigm exploding discoveries. It also encompasses the types of creativity that can lead to everyday breakthroughs and recognises the enormous potential for creativity in collaborative enterprise.

Whilst 'Eureka!' moments still occur, it’s rarely an individual or a single breakthrough that pioneers development. Our knowledge is more often enhanced by the incremental progress that comes about through collectively reconfiguring problems and situations.

Creativity and your research environment

As our understanding of creativity develops, so does our appreciation that an individual’s skills, talents and knowledge are not the only factors that influence their ability to think and work creatively. The physical, social and cognitive, or intellectual, environments in which we work are also significant to our levels of creativity.

This means that as a PGR, your ability to develop and use creativity is influenced by a combination of individual and environmental factors. Some of these factors can stimulate creativity. Others can inhibit it.

Part three of this guide concentrates on the environmental factors that have been found to be significant in stimulating the creativity of PGRs working across the STEM disciplines. It provides practical guidance on how you can change your research environment to make it a more creativity-friendly place to work.
Is it possible for a microbiologist, a theoretical physicist or a chemical engineer to research creatively? And if it’s possible, is it practical? These are valid questions, but the answer to each of them is: ABSOLUTELY! Here’s why.

Creativity and your PhD

Although much postgraduate research does require precision, rigour and repetition, this doesn't mean that it can’t also be creative. In fact, creativity can be used at nearly every significant stage of the research process, as well as in day to day research activities. Creativity can be particularly helpful in:

• Generating original ideas
• Designing your research methodology and choosing your methods
• Constructing and reconstructing your experiments
• Analysing your data
• Disseminating your research findings

What do PGRs think about creativity?

Postgraduate research in STEM disciplines often requires methodical preparation, repetitive data collection and rigorous analysis, delivered within strict budgets and tight time-frames. It is understandable then, that some researchers wonder where being creative fits into the picture.

Their PhD seems to provide little scope for imagination or innovation, novelty or originality. Nor does it leap out as a golden opportunity to exercise creative freedom, imagine, build or try out something completely new and untested.

Creativity can be seen as ‘airy fairy’ and being creative as exercising a freedom which appears to contradict or threaten the discipline and control so integral to much STEM research.

On the other hand, developing and using creativity is important both to becoming a good researcher and a successful PGR to developing your intellectual curiosity and sense of adventure; to pushing the frontiers of knowledge – both your own knowledge and the wider corpus of knowledge in your subject area; and to making a personal and original contribution to your field of research.

For PGRs who appreciate the centrality of creativity to their work, their PhD is not simply a period of amassing technical knowledge; it is an opportunity to try out new and exciting ideas.
We spoke with PGRs and their supervisors about what they felt helped, or hindered, their creativity at work. Three aspects of the academic research environment stood out as having a significant impact on levels of creativity, regardless of the STEM discipline in which students worked. These are:

- The research culture or community to which you, as a PGR, belong
- The level and quality of communication you have with your fellow PGRs and the academic staff in your research group and department
- Your supervisor’s attitude to creativity, and the time and space that you, in consultation with your supervisor, dedicate to working creatively

These aren’t the only things that can impact on creativity, but they are all things that you, as a PGR can change. From our findings, we have developed three ‘key principles’ which are designed to help you change your research environment for the better and, in doing so, to become a more creative researcher.
Your research environment consists of the physical space where you work every day (your office or lab) and the people you work alongside. The research culture which you’re a part of can be thought of as ‘how things are done’ by people in this context. For PGRs working in STEM disciplines, creativity is most likely to flourish in research cultures that balance support and freedom.

What is a supportive research environment?

IT’S STRUCTURED
A degree of structure is necessary to develop the confidence you need to do creative research. The amount of structured support you require will vary depending on your individual strengths and the stage you are at in your PhD. Nonetheless, an environment where project objectives, timetables and deadlines are clearly communicated and you have consistent and constructive contact with your supervisor is a good place to start when developing creativity.

IT’S SAFE
To bring creativity to your doctoral research, you need to feel comfortable asking lots of questions and voicing your ideas. This means working in a research culture where ‘silly’ questions are positively welcomed and nobody is afraid of being ridiculed for sharing a crazy idea. As a PGR, you are becoming an expert in your field, so it’s likely that your contribution is valid and even if it doesn’t work, it could be the catalyst for an idea that does.

IT’S COMMUNICATIVE
Communication is a shortcut to creativity, but it needn’t be a formal collaboration. Chatting with other PGRs can help you generate exciting new ideas. It can also help you explore, critique and refine them.

What is a free research environment?

IT ENCOURAGES AUTONOMY
Making the transition from undergraduate to postgraduate research involves developing a greater degree of autonomy. While all PGRs require structured supervision, it’s important that you also have a comfortable degree of freedom to learn by pursuing interesting ideas and trying things out for yourself. Your sense of autonomy as a researcher will develop as your knowledge and confidence in the field grow. It is not at all unusual for this to take place during the latter stages of your research. It’s also quite normal to experience days, weeks and even months when you do not feel very autonomous at all.

IT’S INFORMAL
Working in a relaxed and informal environment can boost your creativity by giving you time to focus on what matters – your research – rather than having to worry about office politics. Informal working cultures prioritise quality (what you achieve) over quantity (the number of hours you spend in the lab or at your desk). They also facilitate open and informal relations between departmental staff and students (tip: knowing who is who in your department is a really good start!). Finally, they feel democratic. This means that everyone can participate in discussions and feel that their ideas and contributions are valued.

IT ENCOURAGES INTELLECTUAL ADVENTUROUSNESS
The creativity you bring to your PhD will be influenced by the amount of support you receive from your supervisor. They might strongly encourage you to pursue an interesting lead, to try something out or test an original new idea. To do this, you need to accept that sometimes you’ll make mistakes. Working in an environment where you feel it’s not only ok but expected to try things out
can really help you develop the confidence to take those calculated risks, regardless of the outcome.

**How can I make my research environment more positive?**

It’s an academic cliche, but remember: there really are no silly questions. If you find yourself reluctant to actively participate in meetings, ask other students how they feel about speaking up. If they feel the same, think about who you could approach to help to make meetings more inclusive. If you think you may be more reluctant than others to speak up in group situations, talk to your supervisor or a trusted member of academic staff about what you could do to boost your confidence and your participation.

Discuss your difficulties constructively with your peers. Go beyond simply commiserating with each other when things have gone wrong. Asking lots of open questions will encourage creative problem solving. Try asking questions starting “what if... ”, “how do you know... ” and “what can you learn from... ”.

Don’t forget that you are here as a student. Nobody expects you to know everything and it is perfectly acceptable – in fact, it’s absolutely expected – for you to make mistakes. You can learn a huge amount from failure, so talk to others about what went wrong and why. In this way, you turn what might have been a failure into an opportunity for growth.

If you feel that the balance of support and freedom in your department isn’t working for you, raise it with your supervisor. They may not be aware that you feel you need a little more structured support – more frequent supervision, more active input – or a little more autonomy over your day to day work. Telling them this will encourage them to find ways to help.

“To be creative you’ve got to fail... a lot. You’ve got to have stupid ideas that would never work and then you’ve got to figure out why. If you feel that you’re in an environment where you can fail and it’s not going to be the end of the world, then you will learn and progress”.

Postdoc, Natural Sciences
Two modes of communication have been shown to be particularly significant in stimulating creativity amongst PGRs: these are informal and formal communication.

If you already work in a positive research culture, these tips can help you to enhance it. If, on the other hand, your group or department isn’t that communicative, you might feel that there is very little you can do to change it. In fact, there are some simple things you can do to make a difference.

Informal communication

THIS CAN TAKE PLACE:

» **At work:** Having a coffee, taking lunch together or even simply chatting in your workspace with other PGRs and members of your research group

» **Away from work:** Socialising with other PGRs during a planned evening out, playing for – or supporting – a departmental sports team you’ve joined or created, or attending an away day with members of your group or department

THE BENEFITS:

Whilst chatting with your lab partners or office mates might not feel very productive, you are actually cultivating an invaluable resource – one which will help and guide you throughout the course of your PhD (and beyond).

Taking time to get to know the people you work with helps you build a network of researchers with whom you can share your worries, ideas and experiences of postgraduate life. It’s hardly surprising that working in an environment where people invest time in communicating informally with each other has been shown to help counter feelings of isolation and loneliness.

Chatting with other PGRs is good for your research too: it provides time and space to share important information about what’s going on in your field, such as new journal articles, upcoming conferences or new breakthroughs.

Other students provide a vital sounding board you can use to generate, explore and critique new ideas. Bouncing ideas between you can also help you to clarify and refine them, enhancing your capacity for thinking creatively and speeding up your learning process.

Working on the basis that ‘two heads are better than one’, sharing your ideas can help you when you’re stuck – or even prevent you getting stuck in the first place.

Sharing your ideas with other PGRs in an open, safe and informal environment can help increase levels of trust, meaning that you are more likely to feel safe asking for and receiving information and assistance from them in future.

Communication is vital to creativity, so it makes a difference if you work in an open and encouraging environment where you feel free to share ideas with other PGRs and to seek information and advice from academic staff. As we have seen, this is one of the attributes of a positive research culture.

Principle two: Communicate
Talking through ideas in an informal environment can be exactly what you need to stimulate your creativity. That’s why students often say that their best ideas are generated when they’re chatting informally in the café or pub with friends, rather than when they are at work in the lab or office.

Formal communication

**THIS CAN TAKE PLACE:**

» **In your research group or department:** When you have productive meetings or brainstorming sessions

» **At faculty or university level:** When you attend seminars, talks or other activities outside of your department or your immediate field of research

» **Beyond your university:** When you interact with other PGRs and academics from outside your university at conferences and open seminars

**THE BENEFITS:**

Most departments or research groups organise periodic meetings which PGRs are required to attend. These meetings can take the form of progress report sessions, discussion groups or seminars. But not all of these are constructive.

**CONSTRUCTIVE FORMAL COMMUNICATION IS:**

» **Open:** It takes place in an environment where everyone feels safe to share their ideas, ask questions, discuss problems and elicit help and advice

» **Safe:** It creates a space where people are encouraged to feel that there are no silly questions or stupid comments, just ideas

» **Democratic:** Where knowledge is exchanged horizontally across all participants rather than being dispensed by senior academics

» **Supportive and encouraging:** Where students can receive constructive critique without fear of rebuke or ridicule

» **Intellectually adventurous:** Where all group members are encouraged to think big

If you don’t feel that the formal communication in your department is as constructive as it could be, there are lots of practical things you can do to change that. You’ll find that most supervisors and group leaders will be receptive to these ideas.

In a climate of tight deadlines and high expectations, interrupting your research to attend a conference or even take a long lunch can feel like a luxury you can’t afford – or worse, like a waste of time. In fact, the opposite is true; communicating is integral to your work as a creative researcher. It helps create and sustain vital support; facilitates information sharing and most importantly, provides a forum for you to shape, test and improve your creative ideas.

“It’s useful to see what other people are doing, and how they’re coping with their PhD and all the problems associated with it ... Information then travels, you know, about conferences, and who’s doing what. We sort of hang out in each other’s offices and see what everybody’s doing. That’s useful...it gives you slightly more courage to try new things because you see what other people are doing and see it’s fine. It’s a bit of inspiration, I guess.”

PhD, Natural Sciences
How can I make my research culture more communicative?

» Get to know people. Make a point of talking to some of the people you don’t know very well in your department.

» Get out of the lab or office for tea, coffee, lunch or after work catch ups with colleagues.

» Organise an away day, or just an ‘away lunch’ where you can spend time socially with your group or members of your department. Invite as many people as you like.

» Be persistent. If you’re organising events in a department where people aren’t used to socialising, it might take a while to get people on board. But with a little perseverance, you can make it happen. Don’t forget to enlist willing helpers.

» Start a weekly journal club with fellow PGRs. These are a great way to share and discuss knowledge and ideas in an informal setting. Don’t forget the tea and biscuits!

» Try brainstorming techniques with your research group to spark creative ideas, share knowledge and promote discussion. Bouncing ideas between colleagues in an environment where everyone feels safe to ‘think out loud’ can help generate really creative solutions to tricky problems.

» Change the way you communicate in group meetings:
  - Make group meetings about sharing success in a positive atmosphere not simply reporting, housekeeping and troubleshooting.
  - Introduce some democratic working principles to change the dynamic of team meetings. For example, suggest rotating the chair at meetings. This helps establish the principle that everyone can contribute ideas on an equal footing, regardless of their position.

Become part of a wider research community. Look for inspiration outside of your work environment by attending lectures, seminars and conferences. These events don’t need to be in your immediate field. If they look interesting, or you know the speaker is really good, you will likely come away feeling inspired. You might meet some interesting people too.

Organise a postgraduate poster day or symposium to share information about who is researching what. You could extend the invitation to PGRs in your department, the faculty or even your university. These events help you build valuable networks and you might be surprised at who you meet, what they do and how you can pool valuable knowledge, ideas and resources.

“In our group meetings... the idea is that everyone gets up and says what they’ve been doing and they bring their problems. So you have an environment where the new people who come in are petrified because they’re going to have to get up and say something and they don’t want to be wrong. And the whole idea is that this is the place you can be wrong and we’re going to talk about it. We’re not going to jump on you for it, we’re going to talk about it and try and evolve it and develop it and try and understand what’s happening”.

Supervisor, Natural Sciences
Principle three: Negotiate creativity with your supervisor

Your relationship with your supervisor will influence your PhD in many ways. Two of these are particularly significant to your ability to develop and use creativity.

» Your supervisor influences the amount of time and space you have to be creative
» Your supervisor helps determine the level of support and freedom that you are given to conduct your research

Having time and space to try out new ideas and having both the support and the freedom to do so are critical to the development of creativity.

Time and space

Pursuing interesting findings that emerge from your data; learning by playing, trying things out and making mistakes (then figuring out how to fix them) are all important creative processes for PGRs to engage with.

Time and space to think

Having time and space to think is vitally important for your creativity. Whilst you can dedicate time to thinking through ideas at work, thinking things over outside of your workspace can also be productive. Some PGRs find that walking, swimming or going to the gym can help stimulate creative ideas. Others find they are most creative when they ‘switch off’ from an issue or problem altogether.

Time and space to learn by experimentation

Having room to find out how things work by trying them out yourself, playing around with them and making (lots of) mistakes is also vital to develop your creativity. Playing is a great way of learning, and making mistakes, though often less fun, is an unavoidable aspect of creative research. Trying – and failing – is a valuable learning process. Discovering where your idea or experiment went wrong is often as instructive as getting it right. Although not every experiment will be written into your thesis, you can often make use of the results of failed experiments.

Time and space to pursue interesting and unexpected leads

Being creative involves looking out for unexpected findings which can emerge during experiments or during data analysis. These might be easy to overlook, particularly if they don't relate directly to your research. If you do come across something you think is worth pursuing, ask your supervisor if you can spend a little more time on it. You might find that your calculated risk – that is, deviating from a deadline – pays off in the form of an exciting and unexpected result.
How can I negotiate time and space for creativity with my supervisor?

If your supervisor is intellectually adventurous and tends to pursue interesting new findings and ideas, they are likely to see this as a fundamental part of the research process and to encourage you to do the same. If, however, your supervisor is more process and results driven, then negotiating time and space for creativity is less likely to be a consistent feature of your research processes. Regardless, there are things that you can do:

» Talk with your supervisor about the amount of time and space you currently have to work on creative ideas. If you feel it’s insufficient (or non-existent), try to negotiate more. You can start by asking for time to try out an exciting new idea or approach.

» Stay on the lookout for creative directions. If you find something new and potentially exciting which you think is worth pursuing, ask for support in doing this. Make sure you discuss what you learned from this type of work with your supervisor, regardless of the results.

» Make it a policy to share the exciting parts of your research with your supervisor as well as the frustrating or problematic aspects. This is particularly important if your supervisor is process driven.

Support and freedom

Principle one outlined the importance of working in a research environment that is both supportive and free. This section will help you to negotiate the balance of support and freedom with your supervisor. A supportive supervisor can help you structure and project manage your research and advise you on taking calculated risks. The right amount of support from your supervisor can help you to build the confidence you need to be creative. But trying things out, playing with data, taking risks and experimenting with new ideas also requires a degree of freedom and autonomy.

Achieving and maintaining a balance of support and freedom that works for you is an ongoing process, and will depend on your individual talents, skills and needs. It is also likely to fluctuate as you work through the different stages of your PhD, so the type and degree of support you require from your supervisor in the first year of your research is unlikely to match your needs as you approach completion. It is worth checking, periodically, that you are working with the right balance of support and freedom.

HOW CAN I NEGOTIATE A BALANCE OF SUPPORT AND FREEDOM THAT WORKS FOR ME?

Sometimes, you might feel as if the balance of support and freedom you currently have is holding you back rather than helping you move forward. It might be that you need a bit more support from your supervisor, or that you are ready for them to step back and give you more freedom. While it’s not unusual to feel as if you have very little influence over your supervisor, you are not powerless.

» Evaluate: Think about the amount of support and the amount of freedom that your supervisor currently gives you. Being as honest as you can, evaluate your strengths and weaknesses, and ask whether this balance is appropriate.

» Act: If you feel that it would benefit you to change the current balance of support and freedom, raise the issue with your supervisor. They may not be aware that more structured support, or greater freedom in your day to day work could really benefit you and your research. Remember to be specific about the changes you would like to make – asking for help to become a better researcher should encourage your supervisor to look for ways to facilitate it.

“I see a lot of people who research and if you ask them about their lives outside their field there is nothing there and I think that is a very poor creative process. You have to have broad horizons – I’m not thinking of just research but of art, literature, music... Whatever your profession is, you have to have interests outside your field. It really relaxes you but also... you might become more effective in your work without even realising it”.

Postdoc, Natural Sciences
The last section focussed on what you can do to enhance your research environment to make it more creativity-friendly. This section has tips and techniques you can use to enhance and sustain your personal creativity.

**Try to do research you find interesting**

An underlying interest in your subject and a belief in its value can really boost your motivation. Not only does this impact on your creativity on good days, it can also help sustain you on those days when nothing goes according to plan.

**Manage your expectations**

Any PGR will tell you how wonderful it feels when things go well and how frustrated you can feel when they don’t. Being a creative STEM researcher means finding ways of dealing with this ebb and flow. Here are some practical tips:

- **Perfect is the enemy of good!** Think about how you can develop strategies to combat perfectionism. This will boost productivity and help minimise frustration.

- **Fear of failure** is a very common concern amongst PGRs. Whilst for some it will come only occasionally, for others it can be a constant worry which gets in the way of their research. Think about who might be able to help you: fellow PGRs, postdocs, other members of academic staff and your supervisor are all options.

- **Look for strategies for getting through the boring bits** (and there will be boring bits).

- **Think about your work-life balance:** This technique has a ‘work’ component and a ‘life’ component. The work component involves looking for new places to work. Broaden your horizons and look for inspiration outside of your office or lab—take a problem to the local park or to any location you find inspiring. Be careful not to let your work become your life. Having a social life apart from your research is vital to build and sustain the stamina you’ll need to complete your PhD.

- **Share your passion.** Try communicating your science to a non-academic audience. You might find that talking about science to an enthusiastic audience boosts your own enthusiasm.

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**“I love going to the school and watching the kids... it’s the look on their face when you’re teaching them something and suddenly they understand it and it all makes sense and the whole world is right again and it’s great”**

Postdoc, Life Sciences
Achieving balance

This guide has described some things you, as a PGR, can do to make your research a more creative process. Your power to influence your environment may be limited. You may only wish or be able to act on a few of the suggestions made. Nevertheless, it is worth remembering that even small changes can make a big difference to results.

Every academic department, lab and research centre is different. Each constitutes a unique research environment, with its own individual culture. Some aspects of this culture will help you be creative. Others will make it more difficult. Your experience of research environments will also be influenced by the qualities and abilities you, as an individual, bring to your research. These, in turn, are likely to change over the course of your PhD, as you learn new skills and techniques, grow in confidence, adopt more responsibility and attain greater independence as a researcher.

Because of this, there is no algorithm for doing consistently creative research. Making space for creativity is itself a creative task, one that is often achieved by striking a balance – sometimes known as a creative tension – between too little of a factor and too much. The freedom to pursue ideas needs to be balanced by the structure of reasonable project targets and deadlines. Similarly, having unlimited time and space to try out new ideas would soon become as unproductive as working with insufficient resources.

In carrying out the research for this publication, time and again we observed that people who worked in creative environments were more likely to be motivated, enjoy their work, be invested in it, get on with their colleagues and feel good about their results than those who didn’t.

Therefore, it is worth assessing from time to time how effectively your research environment is helping you in your drive to be a creative researcher. Some simple adjustments, especially if you get your peers involved, could greatly enhance your postgraduate journey.
Other good practice guides are available in this series:

Doing creative research
A good practice guide for postdocs in STEM disciplines
Encouraging creativity in PhD and postdoc researchers
A guide for supervisors and principal investigators

These resources may also be downloaded from:
www.vitae.ac.uk/database-of-resources