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Inter-related issues that impact motivation in biomedical sciences graduate education

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Abstract

The expansion of biomedical sciences has seen a recent boom in the number of graduate students and early career scientists. However, the lack of motivation and increasing departure of graduates from research careers were not well explained in current literature. Elements such as intrinsic motivation and external factors may play moderating or independent roles in altering these outcomes. Using semi-structured interviews, we sought to investigate the role of intrinsic motivation and external factors in shaping biomedical sciences graduate students' and early career biomedical scientists' research experiences, and the impact on their perceived research performance and expected career longevity. Using thematic analysis, our data from 10 graduate students or early biomedical scientists participants from uncover several aspects of intrinsic motivation such as its intensity, foundation and nature, and specific external factors such as the presence or absence of social support, the need for career progression driven by societal pressure, and the nature of the research environment that could all influence the students' and trainees' psychological state of mind. In turn, this could impact their perceived research performance ability, and desire to stay or leave the biomedical research field. Our study provided an in-depth perspective into the underlying reasons for leaving biomedical sciences or the lack of 'feel-good' in research besides competition, funding and publications. This could lead to further discussions on policy changes and interventions that could improve biomedical sciences graduate education and training in future.

Keywords: *Intrinsic Motivation, External Factors, Research Performance, Career Sustainability*

Practice Highlights

- Train supervisors in purposeful and meaningful mentoring skills.
- Enhance mental health support for biomedical sciences graduate students and trainees.
- Enhance support in areas that may affect motivation, e.g. family and financial.
- Develop career-proof programs that outline clear learning goals, approaches and outcomes.

I. INTRODUCTION

Biomedical scientists are important members of the healthcare community and developing them is a long-term commitment (Moses III & Martin, 2011). Their education and training enables them to advance healthcare through discoveries and innovations. In addition, they perform imperative roles in health professions education through the integrated teaching and learning of biomedical sciences that can transform

the practice of medicine (Bandiera, Boucher, Neville, Kuper, & Hodges, 2013; Pawlina, 2009).

Many years of education and training are required to nurture each biomedical scientist to be competent in the field. On top of the general education that biomedical scientists received, they have to embark on building specific domain knowledge through graduate education. Thereafter, graduates often have to devote some years of

postdoctoral work prior to becoming independent biomedical researchers, which is the eventual desired educational outcome. Indeed, continuing workplace education is required to enable them to discover, innovate and solve problems within and beyond their domain knowledge. Given such long-term and extensive investments are required to nurture biomedical scientists, it is therefore, disappointing that many promising graduates often leave biomedical sciences to pursue other non-related careers, while those in training often face declining scholarship and performance during the course of their education (Callaway, 2014; Fuhrmann, Halme, O'Sullivan, & Lindstaedt, 2011; Gould, 2015; Powell, 2015; "There is life after academia," 2014).

The problems that plague biomedical sciences graduate students' and early career biomedical scientists' education and training have long been acknowledged and deemed far too complex to understand or solve (Bourne, 2013). Declining motivation, high pressure and stress, thinking in silos, negativity and narrow perspectives are but a few of the problems that we observe in Singapore. Research has shown that biomedical sciences students who are inclined to remain in biomedical sciences education and research have stronger 'taste for science' (Roach & Sauermann, 2010), focus on communal utility value (other-oriented) and not just agentic utility value (self-oriented; Brown, Smith, Thoman, Allen, & Muragishi, 2015), and supported by faculty mentoring (Lopatto & Williams, 2007; Rockey, 2014). However, how these factors contribute to motivation in biomedical sciences remains unclear. They also do not sufficiently explain the problems we observed in the biomedical sciences graduate education system of Singapore and possibly elsewhere. While the shortage of biomedical sciences jobs in academia and industry may contribute to the decline in motivation, it does not sufficiently explain our observation of declining motivation during graduate

education or early post-PhD training that is independent of career opportunities.

Based on these observations and literature review, we developed a conceptual framework to investigate constructs that may affect motivation with perceived research performance, and career choice and sustainability as end-educational outcomes (Figure 1). These constructs are need-for-cognition, need-for-closure and intrinsic motivation. Briefly, need-for-cognition refers to an individual's desire to engage in effortful cognitive activities for enjoyment (Cacioppo & Petty, 1982). Need-for-closure refers to an individual's need to seek closure to questions and extent of discomfort in dealing with uncertainty (Roets, Kruglanski, Kossowska, Pierro, & Hong, 2015). Finally, intrinsic motivation refers to an individual's likelihood to invest effort towards objectives based on innate reasons such as personal interest and attitudes (Koestner & Losier, 2002). This is highly dependent on the individual's sense of autonomy, competence and purpose (Ryan & Deci, 2000).

Our preliminary work suggested that motivation inclined towards need-for-cognition, are more likely to lead to better performance in training and continuation in biomedical sciences careers, given permissive external conditions such as funding and availability (manuscript accepted). These are individuals who enjoy figuring out solutions for difficult puzzles, demonstrate knowledge-seeking behaviour and are inclined to devote effort towards goals based on their desire for improvement and self-interest instead of external pressures (Cacioppo & Petty, 1982; Koestner & Losier, 2002). However, this does not explain 1) why some individuals are more motivated than others, 2) the mechanism of constant cognitive exertion on performance in biomedical sciences education and training, and 3) the external factors that influence this.

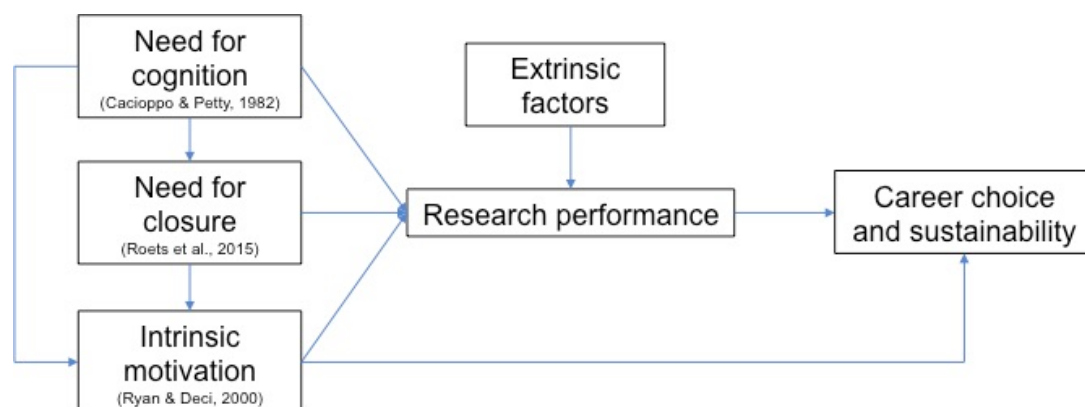


Figure 1. Conceptual framework shows the interaction of various constructs affecting motivation and extrinsic factors on perceived research performance, and anticipated career choice and sustainability

Through seeking to explain this framework further, this study aims to obtain an in-depth understanding of

motivation for biomedical sciences graduate education and training. In doing so, the study seeks to deliver novel

insights that will guide the development of policies and curricula for future training of biomedical sciences graduate students and early career biomedical scientists, not just in Singapore but especially for institutions in Asia whereby they share greater similarity with Singapore in terms of context, background and culture.

The research questions are: In the perception of biomedical sciences graduate students and early career biomedical scientists,

1. How does intrinsic motivation affect them during graduate education and training?
2. What are the external factors that may affect them during graduate education and training, and how?

II. METHODS

A. Methodology

We addressed our research questions through a qualitative study using semi-structured interviews. A qualitative study will allow us to obtain and understand the underlying reasons and rich meaning of participants' choices, decisions, attitudes, behaviours and viewpoints. This is because qualitative research is flexible to elicit more answers, describes variation and explains relationships either individually or as group norms (Sullivan & Sargeant, 2011). This qualitative research seeks to drill deeper into our preliminary questionnaire, which revealed that participants who were more intrinsically motivated tend to do better in training as well as choose to stay on in biomedical-related careers (manuscript accepted). Enjoying cognitive activities and external factors also help to better training performance (manuscript accepted). Therefore, semi-structured interviews were chosen to obtain deeper meaning from underlying reasons rich in context and experience, behind these questionnaire findings.

The interviews were conducted at Centre for Medical Education (CenMED), National University of Singapore (NUS) and involved Yong Loo Lin School of Medicine, Faculty of Science and NUS Graduate School for Integrative Sciences and Engineering, which offer discipline-specific or inter-discipline graduate programs in biomedical sciences as well as running laboratories that offer diverse training opportunities for early career biomedical scientists. CenMED acted as the third party to carry out the semi-structured interviews, independent of the investigators, to avoid bias due to vested interest in the study. CenMED contacted and recruited participants for the semi-structured interviews. The Principal Investigator (PI) provided documentation for the interviews such as interview questions and interview guide as well as briefed interviewers on the objectives of the research, context and background of the participants

and study. For personal data protection purpose, participants were asked to authorise their consent accordingly and informed about the safeguard and confidentiality of their responses through anonymity or composite stories. Audio recordings of the interviews were transcribed verbatim by a transcriber and verified manually by the PI.

In this qualitative study, our approach of using semi-structured interview was informed by the literature on attrition and previous quantitative data collection. Subsequently, the 'hows' and 'whys' are inductively generated from the interview data (Al-Busaidi, 2008). As far as possible, quality standards were applied to this qualitative study in accordance with the Standards for Reporting Qualitative Research (O'Brien, Harris, Beckman, Reed, & Cook, 2014). Semi-structured interviews are also flexible and allow rich data to be obtained such as the views of and descriptions by participants that may reveal unexpected issues or concerns (Pope, van Royen, & Baker, 2002).

B. Context

At NUS, we observed an anecdotal decline in biomedical sciences graduate students and early career biomedical scientists, with those remaining in the field often facing uncertain, poor or mismatched employability. We also observed an anecdotal concomitant decline in motivation and direction amongst graduate students and early career scientists with respect to biomedical sciences research. Students tend to express the wish or desire to 'just focus on their research and graduate' and are observed to be increasingly less participative in research-or academic-related activities. This is comparable to the situation in other countries (Callaway, 2014; Fuhrmann et al., 2011; Gould, 2015; Powell, 2015; "There is life after academia," 2014). Typical graduate programs take 3 to 4 years to complete with some graduate students extending for 6 months to a year. Graduate programs offer varying but competitive stipends, and can lead to a direct PhD or exit with Masters. Graduate curricula vary according to programs, schools and faculties. Typically, candidates admitted to the graduate programs will undertake research under the supervision of staff members from the school or faculty for their period of candidature, at the end of which, they submit a thesis that is examined by a Board of Examiners. In addition, they are required to fulfill a coursework component. Other perks such as conference allowance vary according to programs and student profiles. Training conditions for biomedical sciences graduate students and early career biomedical scientists vary according to labs and supervisors. There is no fixed training period for early career biomedical scientists. Majority of graduate students and early career

scientists hail from Singapore and regional countries such as China, India and Malaysia.

C. Participants

Participants were purposively sampled (Tavakol & Sandars, 2014). The criteria of selection include biomedical sciences graduate students or early career biomedical scientists engaged in graduate programs or postdoctoral training in the above-mentioned schools and faculties in NUS who volunteered and consented to participate in the interview. The composition of participants consisted of almost equal representation from both genders, with a mixture of Singaporeans and regional nationalities. For this study, data saturation was achieved after interviewing 10 participants. In other words, sufficient quality data has been collected to crystallise themes and sub-themes in our study, and that no new theme or sub-theme emerge from the data collected through further sampling of the tenth participant. At this point, no further sampling or data collection is required as the themes and sub-themes are rich and distinct enough for a framework or theory to be developed.

D. Analysis

The transcribed data was analysed using template analysis, along with the interviewers' notes and memo writing where applicable (Brooks, McCluskey, Turley, & King, 2015). Different parts of the text were highlighted and indexed according to themes that were considered relevant and important. Themes were constructed through interpretation of the data. These themes helped to enrich or further shape the framework. During template analysis, codes were developed and collectively interpreted from the data as themes. Upon immersing and dwelling on the data, sub-themes were also interpreted from within these themes. Codes that did not contain useful data were discarded and codes with minimal data were combined (Brooks et al., 2015). As new themes were constructed, participants were recruited for further data collection until the 10th participant whereby no new major theme was identified after the interview. Trends and relationships were also generated from the themes during analysis. Reflexivity was applied throughout the analysis to ensure a more effective and impartial analysis by considering the biases, assumptions and preconceptions that the interviewers and investigators might have during the course of the research. The analysed findings and interpretations were shared with 5 to 6 participants and about 20 to 30 peers in the form of informal meeting and presentation to seek their confirmation and further opinions.

III. RESULTS

Three major themes are important in influencing graduate students' and trainees' experience during their education and training. These are 'Intrinsic Motivation', 'External Factors' and 'Psychological State of Mind'. However, the sub-themes that emerged from the main themes and the relationship among the main themes and sub-themes helped to expand the existing framework, provided greater clarity to understanding their motivation for doing biomedical sciences, and what enhances, sustains or kills their motivation (Figure 2).

A. Theme 1–Intrinsic Motivation

There are several reasons why some participants are intrinsically more motivated than others to commit to biomedical sciences training. These reasons are the intensity of their motivation, the foundations of their motivation, and the nature of their motivation.

Sub-theme 1–Intensity of Motivation: As mentioned below, an intrinsically strong motivation in coming to terms with the purpose of knowing the 'why' of what they are doing will pull students and trainees through difficult times. This high intensity intrinsic motivation sustained over a long period of time is required to overcome frequent challenges in biomedical sciences education and training, as it is often easier to give up than sustain in the field.

"If you don't really have the right motivation in the first place, it is easy for you to just 'let's not do this anymore' ... so I think you need to have strong motivation to do this in the first place. With whatever kind of work you are going to do, you need to have a reason that will pull you through the tough times, ya... if not it's not going to help you last through the tough times."— Participant 1552 (3rd Year graduate student)

Sub-theme 2–Noble Purpose: In order for high intensity intrinsic motivation to be sustained over a long period of time, it needs to be fueled by a greater sense of purpose that is dependent on the character of the students and trainees, which is in turn, shaped by their previous experiences, intrinsic convictions, cultural and educational backgrounds. This helps students and trainees to be able to cope better, stay on course, keep the 'vision' and recover from setbacks during their rigorous education and training. As a result, these students and trainees are also more likely to feel positive, motivate themselves to perform better, and continue on the research path. An example of this is the desire to do good science with integrity and be a role model to the scientific community.

"I think... would be... integrity? Because I don't think my project has actually much clinical value in the sense that there's a lot of grey areas so we can't really make any clear-cut conclusions, so what pushes me to... overcome these research challenges is my want to report honestly, because I feel when I read papers, sometimes... the findings can be exaggerated? Or not entirely true, in the sense that people normally report good things, they don't really report bad things. So... if you're asking me what motivates me to perform better as a researcher, it would be to... put the truth across, to not be afraid to tell people is this what I found, this is not great but this is how it is..."—Participant 1152 (2nd Year Graduate Student)

Sub-theme 3—Types of Intrinsic Motivation: Participants mentioned several types of intrinsic motivation in biomedical sciences that they find rewarding and enjoyable. These deep-rooted desires motivate participants when pursuing their biomedical training. Firstly, the desire to be cognitively challenged promotes better training performance by contributing to the participants' motivation to persevere despite repeated failures. Secondly, growing and sustaining the innate curiosity and passion to seek answers is an important element of intrinsic motivation for students and trainees to pursue biomedical research, which is largely dependent on educational and cultural upbringing.

"I don't know if you heard of it, it's like videogame theory, that you always have to make the next level slightly more stimulating but not that hard that the person will quit, but like hard enough that the person is willing to continue and it's challenging enough that they won't get bored."—Participant 1440 (3rd Year graduate student)

"I think you survive on one part is your passion, your interest generally for studying this field, another thing is you try to cultivate this kind of interest to keep up, to keep going..."—Participant 0855 (Graduate student)

Lastly, the ability to deal with uncertainty during biomedical sciences training brings an important balance to intrinsic motivation. A poor ability to cope with uncertainty is likely to chip away at intrinsic motivation. As research does not always produce successful outcomes, students and trainees have to be mentally prepared to accept a certain degree of unpredictability. A clear understanding and acceptance of this philosophy will help them to last the extra mile. Taken together, it shows that the nature and character of each individual's intrinsic motivation is likely to determine perceived future performance and sustainability in biomedical sciences research.

"Maybe for some reasons, the experiment didn't go very well so they don't have much achievement, so they don't feel these achievement.... They are probably feeling that it is more important to get something for them ... like... very high chance to be recognised or get something done, however, it's something unpredictable in the future, for people don't like this uncertainty or don't like these unpredictable stuff, they probably think ok... I guess it's probably better to go to the company or something."—Participant 0855 (Graduate student)

B. Theme 2—External Factors

In terms of external factors that may enhance or hinder motivation in biomedical training, which in turn, affects perceived performance and decision to remain in research career path, they can be classified broadly into social support, career advancement and research environment. These external factors together with intrinsic motivation can moderate each other and ultimately, impact the psychological state of students and trainees during their education and training.

Sub-theme 1—Social Support: For social support, the three main stakeholders are supervisors, peers and families. It is important for these stakeholders to create a strong support network that will enhance the likelihood of students and trainees staying on in biomedical sciences and doing well. Supervisors' support plays an important aspect in motivating students and trainees to strive for excellence while providing that much-needed emotional and mental support. Supervisors require discipline knowledge in order to support them during times of discipline-associated difficulties as well as possess competencies in supervisory and mentorship skills. Conventionally, most would assume that supervisors are experts in the biomedical science field that their trainees are involved in as well as being skillful in supervision and mentorship. However, our study revealed that this might not be the case all the time.

"Right now I have no... minimal guidance. I'm not sure if it's because... the area of neuroimaging we're doing is new in NUS, so we don't have many experts to guide, so I feel perhaps the university could provide a bit more guidance to us students. We have our Principle Investigators (PIs), but a lot of times he himself is not an expert in the field that he's into."—Participant 1152 (2nd Year Graduate Student)

Interestingly, family is one of the most important stakeholders that influence students' and trainees' decisions to pursue, leave or adjust their respective studies or careers in biomedical sciences. This is not unsurprising as the Hofstede model shows that Asians

tend to be collectivistic and inter-dependent on one another (Hofstede, 2011). This implies that Asian students and trainees are more likely to consult their family members or factor family considerations into their decisions. The impact or consequences that these decisions may have on family members is something that Asian students and trainees care very much about. This may be attributed to the economic systems and cultural philosophies that have been entrenched in Asian countries for generations, at least in part.

The final group of stakeholders who are crucial in this social support network are peers. Participants reiterated the importance of having peers who listen to and share their problems, which serve as a vital outlet for relieving stress and seeking solace in one another. Having supportive peers help students and trainees realise that they are not alone in the problems that they face during their education and training. As a result, it helps them to find strength and give them comfort to soldier on.

“It is good to have meetings with fellow grad students so that we can share experiences and then find some common... I mean it’s good to talk about things.”—Participant 1437 (2nd Year graduate student)

Sub-theme 2—Career Advancement: A second external factor that influences students’ and trainees’ decisions to pursue and stay on in higher education or careers in biomedical sciences, is whether they perceived the field to be of value for their career advancement and alignment to their personal goals. More importantly, their striving for career advancement appears to be driven by what they perceived to be expected or required of them from society. However, this sub-theme is dependent on the family considerations of the students and trainees.

“If you want to continue like lecturer or being education, like academic in the tertiary level, so that’s another reason why I kind of committed to finishing my PhD, besides the research aspect. So I think that’s what drives me more sometimes, even when research doesn’t work out, or our experiments fail.”—Participant 1440 (3rd Year graduate student)

“You have to go overseas do a post-doc before coming back to get a faculty position... I mean it’s being said among the graduate community. So there’s this unspoken rule and when it comes to that right, you have to be concern about family, whether you can suddenly just pluck your family from Singapore and move them over, because it’s not an individual decision. If you are single and your parents don’t mind then it’s fine but for me is my father, my parent is a single parent, my father is a

single parent, so it’s not as easy to make that decision when it comes to pursuing academia.”—Participant 1002 (Graduate student)

Sub-theme 3—Research Environment: Participants also discussed extensively on the impact of their education and training environment to their motivation and desire to remain in the field and perceived likelihood of doing well. Some of the factors for a favourable environment include fostering a non-toxic workplace culture that is not unnecessarily hierarchical and having peripheral programmes aimed at developing complementary non-research skills and interests. This helps to protect the mental wellbeing of the students and trainees, which in turn, helps to grow and sustain their interest in the field.

“Their culture was to be more follow seniority, follow positions so... even though the researcher didn’t know what he was doing... That professor will only listen to his research fellow... the team is pushed apart because of this idea of hierarchy.”—Participant 1152 (2nd Year Graduate Student)

“We spend a lot of time doing research and outside of research we don’t really want to do anything that is related to research. So I think in terms of... that could be more support programmes.”—Participant 1440 (3rd Year graduate student)

C. Theme 3—Psychological State of Mind

Both intrinsic motivation and external factors have huge roles to play in moderating the influence from each other, which in turn, determine the psychological impact on students and trainees. This may influence their ability to do well in research and their decision to stay or leave biomedical sciences. Our study seems to suggest that the external factors, research environment and culture specifically, are responsible for creating a negative psychological impact on students and trainees by eliciting fear and stress.

Ideally, strong intrinsic motivation should be reinforced by positive external factors. However, strong intrinsic motivation can be weathered down by negative external factors. When the latter becomes overwhelming, it leads to a negative psychological state that not only affects the mental health of our students and trainees, causing burnout, undesirable behaviours and attitudes, and other dire consequences, but also leads them to seriously consider leaving biomedical sciences research for good.

“Failing is seen as a bad thing... the thing is biomedical research there is failure and you need time to fail to eventually succeed, but then how the academic structure

is set up is that there's no time for failure."—Participant 1440 (3rd Year graduate student)

"Because your fellow lab mates are not keen to talk these topics to you in a natural fashion, then it's like talking to a wall right, you try to bounce off ideas, like you are trying to talk about it, then there's no response. It's a two-way thing."—Participant 1552 (3rd Year graduate student)

IV. DISCUSSION

In order to understand the motivation for performing high quality research as part of biomedical sciences graduate education and training, almost all participants mentioned that they enjoy being cognitively challenged and the intensity of this intrinsic motivation determines their sustainability in the field. This desire helps them to broaden their creative thinking and sustain their determination to succeed in the presence of failure.

Our study also showed that participants are unclear about the training they are supposed to receive and uncertain about what constitutes towards their education. This worsens the current training environment that is pressurising, disorganised, narrow in learning objectives, and centred on a fear of failure. Fear from the repercussions of failure due to a 'pressure cooker' research environment that celebrates positive results with little tolerance for negative ones can lead to unnecessary stress, lowering of self-esteem, diminishing of self-worth, and reinforcing the notion that one is not good enough. Unresponsive peers and superficial relationships with peers due to a competitive environment can exacerbate the situation, leading to a feeling of helplessness. Therefore, it is important for us to rethink and redefine the yardsticks that measure research success and be more accepting of failure. Supervisors should also be supported with programs that develop mentorship skills. Graduate programs and early career training should be more structured and comprehensive with clear learning outcomes.

For such attitudes and restructuring to happen, a paradigm shift in mindset is needed, which must percolate beyond supervisors to senior academic and research administrators as the latter determine the reward and recognition policies that shape the behaviours and attitudes of the former. Only then, will different stakeholders come together and form a partnership in order to reform and restructure the curriculum (Dasgupta, Symes, & Hyman, 2015).

When it comes to why some trainees are more intrinsically motivated to commit to research than others,

our study showed that trainees who are exposed or influenced early in biomedical sciences; have a certain topic in mind; and are driven by curiosity, tend to be more committed in research than those without these attributes. More encouragingly, our study also highlighted several 'right' reasons as the intrinsic motivation to pursue research. These include the desire to help people through research such as finding cures to cancers and neurodegenerative diseases as well as uphold research integrity in biomedical research. Thus, it is important for students and trainees to 'see the big picture' of their research and that they do not lose sight of this 'big picture' even as it morphs and shape-shifts throughout their journey. This needs to be built into the graduate education and early career training system so as to provide them with a sustained sense of purpose and the inspiration to succeed in order to stem the flow of graduates leaving biomedical sciences research.

Not surprisingly, supervisors and peers are important people who can influence students and trainees to do better and remain in research, either directly or indirectly by altering the research environment (Kemp, Lazarus, Perron, Hanage, & Chapman, 2014). In fact, supervisors appeared to create a greater impact than peers. Thus, it is important for supervisors to be competent not only in their field of expertise but also in mentoring, communication, pedagogy and human management. As supervisors are also role models, they often determine the mindsets, attitudes and behaviours of their students and trainees, which can either be further enhanced or damaged by peers. Perhaps less expected was the important role that family plays in determining whether students and trainees enter, remain, press on, slow down or leave biomedical sciences research. In one instance, pursuing biomedical sciences research is perceived as a ticket to move the family up the social mobility ladder through education. In other instances, the desire to spend quality time with the family, set up a young family or take up family responsibilities in terms of caregiving or financial situations, can lead one to leave biomedical sciences research. Family encouragement or discouragement can also greatly influence their decisions to remain or leave biomedical sciences research. Moreover, females tend to experience a greater burden to choose between staying on or leaving research careers for family reasons such as getting married or caring for young children (Lodish, 2015). In order for students and trainees to focus and perform better in research and subsequently, remain in biomedical sciences, it is important that they feel supported in this area and not have to resolve the tension between research and family by themselves. Establishing clear expectations, flexible timelines and defined educational goals, coupled with a supportive environment and social network, may help to overcome this issue.

Other than overcoming a culture of fear-of-failure and transforming expectation pressure into high performance, future training programs need to incorporate mental health support to ensure the well-being of biomedical sciences graduate students and early career biomedical scientists (Evans, Bira, Gastelum, Weiss, & Vanderford, 2018). In line with literature, our study suggested an increasing likelihood of students and trainees' suffering from burnout and mental health issues as well as becoming 'unhinged' from society-at-large in terms of social behaviour (Evans et al., 2018). In one case, a participant who declared to suffer from depression was determined to remain in research so as to help people through science. Referencing the framework, this may suggest that intrinsic motivation to stay in research and extrinsic 'push' factors to leave research are not mutually exclusive.

The issues confronting biomedical sciences research are not unique to Singapore. These include hyper competition in biomedical sciences that discourages risk-taking behaviour, removes time for creative thinking and turns away even the most promising students from the field; and an increasingly protracted and demanding path

to career progression (Alberts, Kirschner, Tilghman, & Varmus, 2014, 2015). This is further exacerbated by the lack of funding and available positions generally experienced around the world (Kimble et al., 2015). However, most of these studies do not take into account how intrinsic motivation and external factors may moderate the experience imposed by these conditions. Furthermore, students and trainees may even leave the field or perceive themselves to be lacking in research ability independent of actual achievements, and competition for funding and positions, suggesting a role for intrinsic motivation and external factors (Roach & Sauermann, 2017).

Taken together, our study revealed the mechanisms on how enjoying cognitive activities may prime trainees for better research performance, resulting in more sustainable research careers (Figure 2). The study also unraveled deeper insights on the basis for students and trainees' intrinsic motivation, the external factors and their inter-relatedness, which may influence their motivation to press on or stay on in biomedical sciences research (Figure 2).

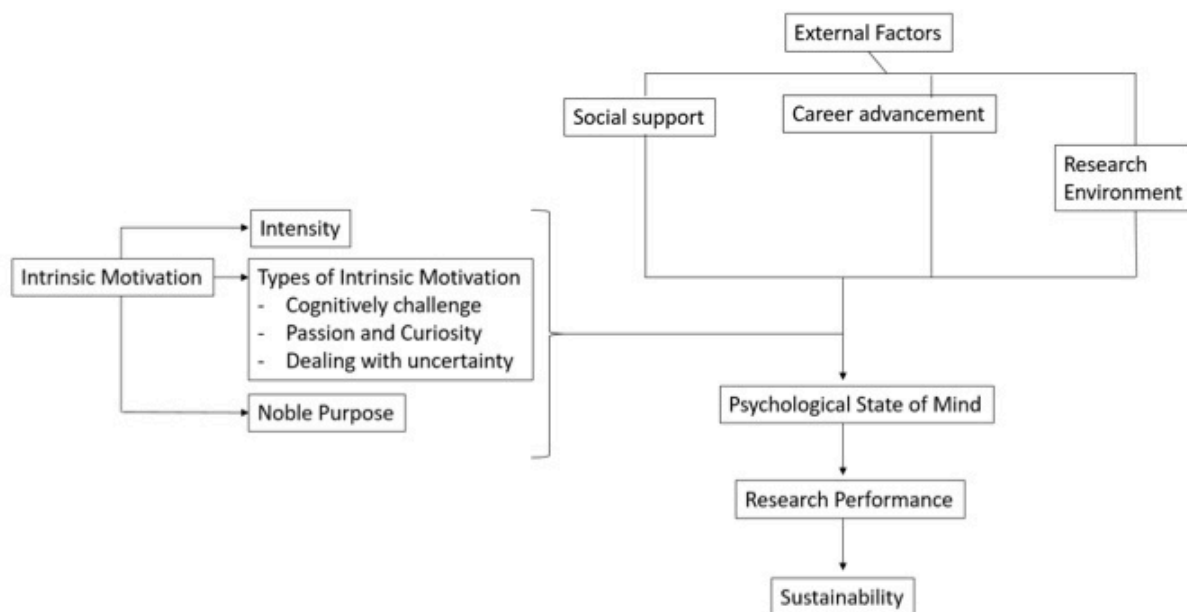


Figure 2. Diagram shows the relationships among the main themes and sub-themes, and their impact on psychological state of mind, research performance and sustainability

Our study emphasised the need for significant changes in graduate education and early career training in order to future-proof and career-proof trainees in an ever-changing employment landscape whereby disruptive technology is creating new jobs as fast as they are destroying existing ones. These changes cannot be token adjustments. They require authentic and transformational leadership to tune in to the needs and aspirations of the students and trainees, match them to Singapore's needs of tomorrow, reduce redundancies and take care of human sensitivities. Some of the key changes include

having more structured graduate and early training programs so that students and trainees are aware of how they are going to be taught, what they will learn, and how they can actively contribute towards their learning with clear objectives and end goals in mind (Bosch, 2018; Dasgupta et al., 2015). Secondly, it is time to put the 'philosophy' back into the 'Doctor of Philosophy' (Bosch, 2018). Currently, many lament that their intense training goes too deep, leaving them with little time and opportunity for other core skills such as communication and management (Bosch & Casadevall, 2017).

Hence, we need to pause, reflect, soul-search, articulate and redefine what graduate education and early career training in biomedical sciences is really all about (Bosch, 2018). There are many worldviews concerning higher education and training but we need to get back to basics, which are for graduate education and early training to be broad, holistic and interdisciplinary to create thinkers, not just doers (Dasgupta et al., 2015; Lorsch & Nichols, 2011). Not only will this create biomedical scientists who are able to think more critically and thoughtfully, it will also enhance the retention rate of graduates in biomedical sciences research.

V. CONCLUSION

Our research will enable policy and decision makers to customise biomedical sciences graduate education and early career training programs that are fit for purpose. This may include providing closer support and proper guidance; developing clear learning objectives, processes and outcomes and following them; introducing education and training components to meet diverse interests; creating opportunities for and empowering students and trainees in ways that will help them to meet their education expectations and career aspirations.

Therefore, our study has provided a deeper and greater dimension as to why biomedical sciences graduate students and early career scientists are really lacking in motivation and leaving the field beyond funding and job availability issues. Given its global nature, we hope our findings will be useful for consideration by institutions around the world, which are offering or setting up graduate education and early career training programs in biomedical sciences especially for Asian institutions. This impetus to extend the call-for-action to other Asian institutions is strengthened by the fact that some of our participants hailed from major Asian countries such as China and India. Their contribution to our overall findings will be as highly relevant for other Asian institutions as it is for Singapore.

Notes on Contributors

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Ethical Approval

This research received approval from the NUS-Institutional Review Board (NUS-IRB; Ref No. B-15-256). Consent was obtained from participants for the research study.

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Declaration of Interest

The authors declare that they have no competing interests.

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