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Navigating the Contemporary Rites of Passage: A Typology of STEM Professional Identity Transition

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ABSTRACT
Anchored upon a renewed rites of passage perspective, this study employs a narrative inquiry to understand how professional identities are enacted, developed, negotiated, and reconstructed among final year STEM undergraduates in Malaysia. While professional identities are largely studied within the workplace or organisational context, there is limited knowledge of how students make sense of their professional identities during their study. To address this gap, this study explores the dilemmas and dreams of twenty-four final year STEM undergraduates as they were at the critical juncture of transition towards their first full-time career. While the participants shared a common experience of STEM professional identity formation during their childhood and adolescent phases of life, there were variations in how individuals negotiated their professional identities as they reached the crossroads upon university enrolment and graduation. In navigating the liminal phase of uncertainties, negotiation strategies included defending and rethinking STEM professional identities while balancing identities in work and non-work roles. Towards the reconstruction phase, a process of redefining, affirming, and securing STEM professional identity takes place as individuals make sense of their roles and place in the communities. The narrative findings illustrate contemporary dynamics of societal expectations, structural forces and personal agency that facilitate STEM professional transitions. The study also adds insights into emerging discourses surrounding STEM education and talent retention strategies among the contemporary STEM workforce.

KEYWORDS
Professional identity; transition; STEM; education; rites of passage.

INTRODUCTION

The Covid-19 pandemic has transformed the world to an unimaginable degree, with its crippling impact upon community health, education, and global economies as new rituals of containment and socialisation are reinvented in almost every aspect of life. For the first time in thirty years, the global human development measurement which captures progress in health, education and living standards dimensions has decline for two years consecutively (United Nations Development Programme, 2022). The developing countries are reported to have experienced a more pronounced impact in the form of a widened gap in gender equality and lack of access to technological infrastructure. As we work towards a global recovery and restoration, there is an urgent need for the next generation to be empowered with science, technology, engineering and mathematics (STEM) education and very importantly, to retain STEM talents to address unprecedented global challenges (World Economic Forum, 2020). In order to achieve these goals, a deeper understanding of professional identity in STEM will be necessary, as it is fundamental to students' persistence in STEM during critical moments of hardship (McDonald et al., 2019).

In response to the sustained discourses surrounding a diminishing STEM workforce, this study employs a narrative inquiry to explore how STEM final year undergraduates, as potential new entrants into the labour market of a developing nation, make sense of their professional identities in STEM at the critical juncture of university-to-work transition. According to Boswell et al. (2012), the term 'new entrants' refers to individuals who are seeking their first full-time positions. To these individuals, finding a job related to their field of study or anticipated career is important for their immediate job prospects as well as for their long-term career trajectories. Beyond these considerations, however, professional identity construction is fundamental to everyone's career success, as each individual internalises the beliefs, values, skills, knowledge and principles of the profession (Slay & Smith, 2011). Career change for science graduates towards non-STEM careers is a common phenomenon, but it represents a loss of investment in developing human capital in STEM, especially through institutional funding such as scholarships from government agencies and corporate bodies. This broader issue calls for a deeper understanding of the factors that contribute towards the construction, development, and negotiation of STEM professional identities amongst the new generation workforce (Nadelson et al., 2017). Beyond skills and knowledge in STEM, Hancock and Walsh (2014) have argued that a neglect of professional identity development is damaging, because the career landscape of contemporary science careers is characterised by complexity and fluidity which have substantial implications for organisational performance, personal identity and well-being.

Alongside Malaysia's aspiration to attain a high-income economy that is innovation-led, and sustainable, the nation is subjected to pressing concerns about the decreasing enrolment of STEM undergraduates and a shortage of STEM workforce (Khazanah Research Institute, 2018). Similar to issues faced by emerging economies such as China, India, and Vietnam, there is a lack of STEM job opportunities for graduates in Malaysia the best talents of STEM

researchers are lost to employers from more highly developed nations (The New York Science Academy, 2014; Azman et al., 2016) or graduates instead resort to better paid non-science careers such as in the banking, consultancy or administrative professions (Abdul Rahim, 2020). Hence, STEM human capital development in Malaysia remains an important agenda to propel the nation to greater heights in terms of innovations and technological breakthroughs.

Purpose of This Study

Based on a renewed rites of passage perspective, this study seeks to understand the contemporary dynamics of societal expectations, structural forces and personal agency that facilitate STEM professional identity transitions in an Asian context. These dynamics are expressed in the central question of this study: 'how is STEM professional identity constructed and negotiated in the context of a developing nation in Asia?'. This area of research is particularly vital in the context of new entrants to the contemporary labour market, who serve as a talented workforce and potential future leaders in STEM. Essentially, this study seeks to contribute to the critical discourse surrounding STEM education and 'university-to-work' transition while offering insights into potential growth and talent retention strategies in the STEM professions.

Career as a Passage of Identity Transition

Occupational endeavours are a major source of personal identity and self-evaluation, and these pursuits tend to structure a dominant part of an individual's everyday reality (Bandura et al., 2001). Because of this significance, there has been a sustained interest in understanding factors that may influence individuals' educational and occupational choices, along with the impact they have upon subsequent career progress (Dodourova et al., 2019). In the contemporary career context characterised by disruptions and uncertainties, there is also a need to explore the stability and variability of career paths in the light of individual trajectories and meaning of progress (Potter, 2019).

A career has been broadly defined as an accumulation of role-related experiences over time (Hall 1987); and later work by Ashforth (2012) described a career as a dance between the individual and the personas of various work roles that entered and exited in their lifetime. While the discourse surrounding one's career attracts much interest in various disciplines such as counselling, education and human resources, the fundamental aim of career research is to understand individuals' experiences as they travel through their professional lives (Briscoe et al., 2011). In understanding career transitions, the 'rites-of-passage' perspective which originated from Arnold van Gennep's anthropological scholarship, sheds light on how community-created or community-directed experiences are instrumental towards abscribing cultural value and knowledge to an individual or a group (Hawkins & Edwards, 2015). The term 'rites of passage' has been defined as '*rites which accompany every change of place, state, social position and age*' (Deflem, 1991, p.7) and which consist of three consecutive stages of experience in the form of separation, transition (or liminal phase) and reincorporation.

With a rites of passage lens, Glaser and Strauss (1971) use the concept of 'status passages' to describe how individuals and groups in contemporary society transition from one status to another (e.g through promotion, career mobility, university graduation). They describe careers as a series of passages from one role to another within an organisational or occupational social system, accompanied by loss or gain of privileges (Armstrong, 2009). This conceptualisation is useful as a way to understand career transition, which is described as a state of change and as "*the period during which an individual is either changing roles (taking on a different objective role) or changing orientation to a role already held (altering a subjective state)*" (Louis 1980, p. 330). As the concept of career has evolved to embrace the spatial and temporal dimensions in life, transitional experiences also feature as transformational stages characterised by unique concerns and themes.

Professional Identity and Possible Selves

Predominantly, professional identity is described as a process through which individuals develop coherent narratives of the self which are grounded upon the broader life story, which the self inherits (Kerby, 1991). The lens of 'possible-selves theory' is useful to understand the complexities and evolving nature of professional identities – which are commonly defined as the constellation of beliefs, attributes, and values which are used to define individuals in specialised occupations or vocations (Slay & Smith, 2011). The 'possible-selves' theory describes how future-oriented thought provides identity-relevant information to pursue self-relevant goals (Markus & Nurius, 1986). Individuals can picture several alternative visions of their possible future and these reflect their hopes, fears, and goals.

Anchored upon social identity theory, a 'possible self' is enacted based on social comparisons and constraints as individuals draw from the role models and images made available by cultural and social experiences (Hamman et al., 2010). The image of future selves develops over time as individuals consider their hopes and aspirations, observe role models and invoke motivational discrepancy which enables the exploration of new possibilities (Strauss et al., 2012). Some individuals may envision themselves as not being able to succeed in the future because of the expected work demand in particular careers. For science career pursuits, environmental factors such as messages about a successful career in science, and social support, are found to be very influential in determining college program choice and career decision (Buday et al., 2012). Furthermore, Chen and colleagues (2020) reported the effectiveness of collaborative teaching with STEM experts and educational researchers in increasing STEM career interest and more positive perception of STEM professions. The positive visualisation of scientific careers is found to be a critical element, alongside ongoing efforts to enhance pedagogical science education.

However, beyond skills and knowledge development, it is advocated that professional identity construction needs to integrate one's sense of self with the professional self, taking on a narrow culturally scripted professional role while maintaining one's individuality (Leijen & Kullasepp, 2013). For instance, McGee (2021) has argued that among Black STEM doctoral

students, their heightened sense of agency as change agents was profound in response to Trump's administration which had induced anxieties towards STEM careers among marginalised communities. Professional identity is also found to be a significant predictor for career change intention (Khapova et al., 2007) as unlike career identity, professional identity assumes a broader meaning that is beyond career behaviours within an organisational setting, and includes aspects of growth and development. In the context of scientific careers, professional identity (of even STEM doctoral graduates) can be compromised as the landscape of contemporary science continues to evolve towards multidisciplinary competencies and collaborations (Hancock & Walsh, 2014). Given the evidence supporting the importance of professional identity in student learning, persistence, and career progress in STEM (Nadelson et al., 2017), there is a need to understand the dynamics of professional identity construction as it is being negotiated in the course of becoming a STEM professional.

METHOD AND PROCEDURES

A purposive sample of twenty-four science and engineering undergraduates from public and private universities in Malaysia were interviewed for this study. The sample consisted of twelve female and twelve male participants; from Malay, Chinese, and Indian ethnic groups. All participants were in the final year of their undergraduate programs, and a majority had received merit scholarships from the government and corporate bodies for their undergraduate programmes in subjects such as microbiology, pure chemistry and engineering as well as in biotechnology, an area which the Malaysian government had identified as one of the main pillars of economic growth in the 21st century. A profile of the participants recruited for this study is summarised in the table below.

The current study employed narrative analysis as a method to delve into rich illustrations of the contextual, historical and futuristic descriptions that offer insights into the process of professional identity construction and negotiation for Malaysian students pursuing their final year science and engineering undergraduate studies. Biographical narratives consist of self-narrated lived experiences that associate the past with the present, and construct the anticipated future (Yoon & Park, 2012). This vital approach is recognised as a way to understand the life narratives of these individuals in STEM professional identity negotiation, as 'now' is a nexus that connects the temporal horizons of the lifeworld (Slay & Smith, 2011). Interview sessions were conducted for approximately 1.5-2 hours and facilitated through a storytelling dialogue. The narrative analysis focused on a chronological approach to the individuals' life stories, which led to a narrative configuration drawing together all significant elements to form the foundation of central themes that underpin both the individual and collective experience (Polkinghorne, 2007). The co-construction of the self and others was discerned through the narrative accounts, highlighting sources of tension, conflicts, and reconciliations. The narratives serve to relate the past and the present, to signify future trajectories that inform the process of professional identity negotiation.

Table 1. *Profile of Participants*

No.	Participant (Pseudonym)	Gender	Ethnicity	Type of University	Course of study	Scholarship Status	Career Considerations
1	Kelly	Female	Chinese	Private	Biotechnology	Merit Scholarship (Government)	Aims to work as a science teacher for work life balance and passion in teaching. Feels that science degree is too hectic, compromising time with loved ones.
2	Zhe Jing	Female	Chinese	Private	Biotechnology	Merit Scholarship (Government)	Did not have a positive internship experience. Prefers to pursue non-science career such as administrative work due to limited job opportunities for new graduates in science.
3	Jun Ying	Female	Chinese	Private	Biotechnology	Merit Scholarship (Government)	Prefers an academic career - pursuing Masters/PhD for the work flexibility and ability to pursue research.
4	Ken	Male	Chinese	Private	Biotechnology	Merit Scholarship (Government)	Plans to pursue PhD (if financially supported by sponsor) and very interested to contribute to society via wastewater treatment business with peers from other disciplines.
5	Siew Lee	Female	Chinese	Private	Biotechnology	Merit Scholarship (Government)	Unsure about career direction, while social status is important to her. Feels incompetence in research career. Perceives that science-based roles in the industry are lower paid than in business or industry. However, will pursue postgraduate studies towards an academic career (if financially supported by sponsor) as it is a respected career and can have autonomy not commonly available in the corporate world.
6	Kai Sim	Female	Chinese	Private	Biotechnology	Merit Scholarship (Government)	Unsure about career direction but hopes to work in an environment that prioritises growth and development. Feels incompetent for a research career. Biotechnology industry is perceived to be under-developed, which contradicts government promises. Believes that science careers include sales and insurance if scientific knowledge is required. Plans to be involved in entrepreneurship and to pursue an MBA.
7	Gavin	Male	Chinese	Private	Biotechnology	Merit Scholarship (Government)	Does not find research career suitable for personality. Pay in marketing roles is perceived to be much higher than science career. Hence, prefers to embark into the marketing profession.

No.	Participant (Pseudonym)	Gender	Ethnicity	Type of University	Course of study	Scholarship Status	Career Considerations
8	Billy	Male	Chinese	Private	Biotechnology	Merit Scholarship (Government)	Feels that science degree is very stressful. Plans to embark in a graduate management programme, and to experience different roles within a company.
9	Muhammad	Male	Malay	Private	Electrical engineering	Merit Scholarship (Government)	Plans to travel on working holiday, pursue a Master's degree, and embark on a freelancing career based on maintenance skillsets.
10	Sharifah	Female	Malay	Private	Electrical engineering	Merit Scholarship (Government)	Plans to pursue postgraduate studies (if financially supported by sponsor for further studies). Would prefer to obtain an education degree and embark in a teaching career for work-life balance. Perceives engineering career for female graduates in Malaysia is limited due to gender inequality.
11	Melissa	Female	Chinese	Public	Product development technology	Study Loan (Government)	Very clear about her plans to assume marketing role in science-based company (food science etc). Does not like to be working in labs. Feels that scientific careers can be wide-ranging beyond R&D. Perceives that training in science will be important for marketing roles.
12	Khatijah	Female	Malay	Public	Actuarial and financial mathematics	Merit Scholarship (Government)	Plans to pursue a Master's degree in a non-actuarial field and embark on an academic career, as job opportunities in the industry are limited and she enjoys teaching. Does not perceive any gender inequality in the finance sector.
13	Selvi	Female	Indian	Public	Microbiology	Merit Scholarship (Government)	Plans to pursue a postgraduate study towards an academic career, because of passion for research.
14	Jevi	Female	Indian	Public	Pure chemistry	Merit Scholarship (Government)	Plans to pursue postgraduate studies towards an academic career as her passion is in research.
15	Terence	Male	Chinese	Public	Microbiology	Study Loan (Government)	Plans to embark on mushroom farming together with peers in the university, in the future. Open to business/marketing job opportunities. Feels that science careers are limited in work life balance.

No.	Participant (Pseudonym)	Gender	Ethnicity	Type of University	Course of study	Scholarship Status	Career Considerations
16	Zhou Yong	Male	Chinese	Public	Microbiology	Study Loan (Government)	Unsure about his preferred career. Enjoys doing research during internship, however, unsure if a scientist career is what he intends to pursue because of the unattractive salary.
17	Labib	Male	Malay	Public	Pure chemistry	Merit Scholarship (Government)	Very sure about pursuing postgraduate studies towards an academic career, motivated by passion for research and the lifestyle of lecturers, presenting at conferences and with flexible working hours
18	Karulzaman	Male	Malay	Public	Pure physics	Study Loan (Government)	Plans to pursue Master's degree because of limited industry opportunities in his field. May consider teaching science if there are not suitable job opportunities in the industry.
19	Kee Sing	Male	Chinese	Public	Biochemistry	Study Loan (Government)	Plans to pursue postgraduate studies because of low salary levels for new graduates.
20	Parvindra	Male	Indian	Public	Biochemistry	Self-funded	Plans to pursue postgraduate studies towards an academic career, as he is very passionate about research, and wants to contribute to society.
21	Amin	Male	Malay	Public	Physics	Study Loan (Government)	Plans to pursue postgraduate studies towards an academic career, as he is very passionate about research, and wants to contribute to society.
22	Tahir	Male	Malay	Public	Pure physics	Study Loan (Government)	Plans to pursue postgraduate studies towards an academic career, as he is very passionate about research, and wants to contribute to society.
23	Jen Wei	Female	Chinese	Public	Chemical engineering	Study Loan (Government)	Plans to pursue a postgraduate professional Engineer. Does not perceive gender stereotyping in the engineering profession. Experienced a very positive experience during internship.
24	Nora	Female	Malay	Public	Materials science	Corporate Scholarship	Plans to work in an administrative field in the corporate. Feels that employers in the industry are not familiar with materials science degrees. Perceives that a science career is not easy for female graduates because of gender inequality, as experienced at the career fair.

NARRATIVE FINDINGS

The Birth of STEM Identity

In contemporary society, professional identity is viewed as the result of the socialisation process, and rhetoric where one is provided with information regarding the meanings associated with a profession (Hall, 1987). These meanings are translated through students' own learning experiences, interactions, and application of knowledge, influencing their professional identity development (Nadelson et al., 2017). A strong, positive STEM identity has been identified as a predictor of future career choice in a STEM field (Martin-Hansen, 2018). During the course of the interviews, the majority of the participants mentioned feelings of attraction and fascination with science during late childhood and adolescent learning encounters, which led in time to the emergence of their professional identity in science. Their curiosity about the subject was triggered by the notable medium of influences including their families, peers, teachers, scientific magazines, and media. A biotechnology undergraduate, Kar Bin shared that:

> *While I was in secondary school, I read a scientific magazine about a researcher who studied the plant tissue culture of an orchid. That article ignited a strong interest in me to know about plant tissue culture for biotechnology.*

At home, interaction with older siblings and relatives provided the opportunity to observe and learn about scientific applications and technology. In schools, passionate science teachers are exceptionally instrumental in inspiring new generations of science students. In addition, enrichment programs such as science fairs, competitions, workshops, and laboratory experiments introduced participants to the universality of science in naturally occurring phenomena which offers opportunities for self-discovery through critical thinking and exploration. For instance, Selvi, a female microbiology undergraduate expressed that:

> *It began with one competition which I took part in when I was 12 years old – it was a national program for all Tamil schools where a junior science competition was organised. It was a significant one because it allowed us to think in many different ways, and we can always be sceptical. That competition made me aware of my passion for science.*

Apart from the catalysts above, the English language featured as an enabling vehicle towards inculcating interest in scientific pursuits at the high school (secondary) level. The participants in this study were the first cohort who had learned science and mathematics in English at the public schools as a part of their secondary syllabus, which was a new initiative undertaken by the Ministry of Education to promote STEM teaching and learning. All participants felt that the use of English helped them to appreciate the subjects in greater depth because they could understand specific scientific terms and could access scientific research resources that are predominantly in English. The following quote by Labib, a Malay final year

undergraduate in a public university demonstrates the importance of the English language in promoting STEM interest:

> *During primary school, I did not like science because it was taught in the Malay language, so it was really hard to understand. When I entered high school, English was used as the language for learning science subjects, and my interest in science grew. When Malay was used in teaching science, I could hardly understand it at times because the meaning can be different.*

Set Apart for Success

In a rite of passage, the first phase is separation, when ritual participants are removed from the outside society in preparation for their change of status; a pre-liminal period of separation from their previous social life (Gibbons et al., 2014). This phase involves a detachment of the former self through symbolic actions and rituals in preparation for the new phase of life which is also experienced as a shared faith with those who transition through the same pathway (Maruna, 2011). The separation phase in the STEM rite of passage can be observed at the point of transition between lower secondary to upper secondary in the Malaysian education system, when students need to choose between a science or arts stream, with science restricted to those who performed well in the middle school public examination. This system sets the high performing students apart from the rest, as these 'chosen' ones ascend to the elevated status of identity as a science student upon proving their worth in the public examination. This juncture of transition into the upper secondary level, denotes a 'set apart' time and space as contexts of marked transformation, growth, and 'becoming' in the scientific community.

Collectively, this transitional phase demonstrates a strong commonality in the process of how participants were assigned to the science stream without making a conscious decision. For the study participants who were scholarship recipients at the tertiary education level, the choice of the science stream at this phase was straightforward because of their genuine interest in the sciences, their excellent results, and their career goals to be doctors, scientists, or engineers. Beyond these individual factors, favourable societal perception of science students as 'smart' and 'hardworking', attractive career prospects in science, and school efforts to divert high-performing students to undertake the science stream also play a vital role in influencing these decisions. For instance, Billy, pursuing a biotechnology degree, shared that her parents perceived arts students as inferior:

> *The government influenced the teacher, the teacher in the secondary school always sees science students as the good students, the smart students, and arts students as bad students, stupid students.*

This sentiment is also shared by Su Peng:

My parents support me to go to science because they perceive that science students are cleverer, as compared to art students. So, they are worried that if you go into art, you will become, your attitude will change will become less clever.

Such discriminatory perception in Malaysian society (including among teachers), inevitably creates an education system that stereotypes arts stream students as lazy, lacking in intellectual potential and career prospects in the future. The choice of the science stream is commonly seen as more versatile, offering individuals the choice to embark upon either science and non-science career options at a later stage. This flexibility, however, does not exist in the arts stream pathway – students would not be able to undertake scientific careers after this decision.

Liminal Space in STEM Careers

The experiences of most participants at the final year of their undergraduate studies are congruent with the "betwixt and between" liminal period described by Turner (1969) when individuals have shed their old identities but have yet to incorporate a new way of being. This transitional state of being is often associated with a period of uncertainty and ambiguity which can be painful, unsettling and disruptive (Bamber et al., 2017). Liminality is, however, a process that offers individuals the rare opportunity to make sense of societal challenges and personal difficulties, as they experience significant tensions, dilemmas and milestones during this process (Cook-Sather, 2006). This transitional phase is observed to be most prominent at the final phase of undergraduate degrees when a majority of participants begin to doubt their potential and future selves in a scientific career, as they come to understand the trade-offs and difficulties that accompany a career in science. A journey into a science career came to feel like a road less travelled as they witnessed peers switch to more common paths in non-scientific occupations that seemed more rewarding. As these final year undergraduates are at the threshold of crossing the boundaries of student role to the sphere of working adulthood, they are subjected to a 'inbetweenness' condition which gives rise to mixed or contradictory identities.

For a segment of participants, significant tensions arose at the point of undergraduate degree enrolment, which tested their determination in preserving their science identity. For other participants, however, liminality also encourages a renewed perspective and provides a sense of freedom where liminal space and time are made meaningful to the individuals (Shortt, 2015). This process of 'anti-structure' as introduced by Turner (1969), allows individuals to feel a sense of agency as they push against structural limits to achieve the triumph of a psychological breakthrough. In essence, the phase of liminality embraces a state of ambivalence that propels efforts in defending, rethinking and balancing their identities, while for some, it remains a state of reconciling with their unmet expectations. The following findings highlight significant moments of liminality in the ritual passages of the STEM final year undergraduates.

Defending Identities

Treading as a traveller through the cultural realms of the STEM rite of passage, science undergraduates experience liminality as they embark upon separate paths of scientific pursuits that will enact a specialised professional identity. While the science stream at high school was viewed socially as a pathway for the 'able' or 'smart' students, study participants of Indian ethnicity reported having wrestled with their parents' demands for them to adopt a professional career path, rather than pure science career pursuits. It is common in Indian culture to place high regard upon certain professions such as medical doctors, lawyers, accountants and engineers, and 'scientist' is not among them. In such a condition, the individual sought self-verification by influencing the other party to conform to the individual's self-view and to achieve intrapersonal harmony. Selvi, an Indian female participant who studied in a public university, expressed her experience in defending her identity as a passionate science student, in pursuit of a degree in microbiology. As narrated by Selvi:

> *My parents wanted me to be a lawyer. There's a big difference. My parents had dreams about each child – my sister is a doctor, my second brother is an engineer. They wanted me to become a lawyer but I refused because it is not my passion, my passion lies in science.*

Jevi and Parvin had similar experiences – they had had to defend their professional identities in pure chemistry and biochemistry respectively, as they believed these pursuits allowed them to contribute to society through impactful research.

Balancing Identities

Professional narratives are seen as an important means to understanding of identity construction and negotiation, as they allow individuals to articulate the importance of their work in relation to others (Fine, 1996). As observed in these narratives, career becomes a sounding board through which perceived selves and significant relationships are intertwined (Potter, 2019). This is observed in these participants as they strove to balance current and future identities (as parents/spouses) while attempting to justify their passion for science. Similar to the bargaining process, the participants recognised the trade-off associated with a future career in science, particularly with the respect that one can gain in the public eye, in exchange for time spent with loved ones. Female participants who were scholarship recipients expressed deep apprehension and confusion in their struggles to cope with their identities as science scholars. This was unlike the fun and exciting nature of science from childhood to secondary education and the affirmative experiences gained from excellent results in high school, their university learning experience involved a complex syllabus, repetitive and intensive laboratory work, and strict deadlines. The demanding courses required them to sacrifice much time and effort at the expense of quality time with their loved ones. As expressed by Kelly who planned to be a private tutor in a science subject:

> *The course was very hectic to such an extent that I felt that I didn't have the amount of time that was needed for my family members. This is because all of our time is taken up on completing the assignments. That was one of the regrets during my degree. I really don't want to do this anymore.*

The majority of the participants regardless of gender, seek a career in academia, as it offers them the opportunity to spend more time with their families. Amin, a physics undergraduate who aspired to pursue a PhD, reported:

> *Someday I will have my own family, someday I will have to take care of my own family, especially because I'm a man. My father told us, we have to balance time between work and family. For me, that's a very deep message. I'm studying not for my own future, but for the next generation.*

Aside from academic careers, a few of the male participants believed that an entrepreneurial pursuit could offer them an environment that would enable them to achieve the work-life balance important for them and their families. For instance, Ken, a biotechnology undergraduate, referred to his brother's hectic career in auditing, which Ken perceived as not worth the sacrifice. Instead, he preferred to be an entrepreneur, as he believed that that path would allow him to make novel contributions to society while still achieving the flexibility he was seeking in life.

Rethinking Identities

At liminal thresholds, students tend to experience symbolic liminal 'monsters' in the form of doubts and anxieties as they progress through new learning experiences (Hawkins & Edwards, 2015). In the STEM passage, liminality is intensified by symbolic activities in the form of academic attainment, research (e.g. final year projects), career fairs and internships, which serve as transformative rites of 'becoming', enacting professional identities of future selves in science. Negative experiences in these rituals of transition result in a prevailing doubt as to the students' capabilities or suitability for a scientific career. Kai Sim shared that *"…I enjoyed scientific research but don't think I'm good at it"* as she felt that she had failed in meeting the expectations of her thesis supervisor. This experience led to the beginning of feelings of uncertainty, and contemplation as to whether the R&D field was meant for her. The sense of helplessness, regret, and lack of competence can be painful for these participants as they had maintained excellent achievements previously throughout their educational journey.

Most participants who had embarked upon an internship expressed a strong sentiment that scientific work in the corporate or private sector is undesirable because of repetitive tasks, office politics, long working hours and demanding work tasks. This temporal engagement 'outside of the ordinary' presented realities besieged with a modest salary and a lack of career prospect which led to a sense of betrayal and disconfirmation of expectations. As mentioned by Gavin, a biotechnology undergraduate:

I have heard that the salaries in this field are not very high, and that the career prospects aren't that good. After undertaking internship, I realise that this is all true.

Terence, who was pursuing a microbiology degree shared that:

Initially, I thought science was a noble job and that the salaries would be very high. But then I realised that to reach a high salary, one needs to study to PhD level.

The rethinking of STEM professional identity was salient for Nora, who pursued a materials science degree. As part of her narrative, Nora had experienced discriminatory remarks from potential employers at a career fair. One organisation's representative told her that they would only consider applications from male candidates as the nature of the work in materials science engineering was more 'appropriate' for men. This experience led to her subsequent decision to be a science teacher instead. Similarly, Sharifah, an engineering student, entered this field because of her strong interest in specialising in electrical and computer systems. However, as she progressed toward the final year of the degree, she became more aware of the gender inequality that exists in the engineering industry:

Guys have so much opportunity compared to girls…I know it's going to be hard to get jobs. But I have a strong interest. I just don't know how I am going to survive.

At a macro level, concerns were raised surrounding the issues of limited research opportunities in Malaysia as a developing nation, as technological infrastructure and funding agencies were more readily available in developed countries such as the United States. A common belief among the participants in the study relate to how fresh graduates in the scientific field, their knowledge and experience would not be sufficient to secure a research position in industry, which usually favours postgraduate qualifications. Zhe Ying, a scholar sponsored by the Ministry of Public Service, responded:

As a new graduate, it is very difficult to find a science-related job, because they need work experience or higher qualifications. I will try my best to get a job but maybe it will be unrelated to science.

Redefining STEM Career Boundaries

While the liminal phase is characterised by dark moments of ambiguity, doubts and uncertainties, this transitional process provides opportunities for self-realisation and renewal leading to transformed identities, as individuals make sense of their roles and place in their communities (Hawkins & Edwards, 2015). As highlighted by Kreiner et al. (2006), people tend to negotiate their unique individual identities by separating or integrating personal identities and social identities. In coping with uncertainties and their pessimistic vision of the science labour market, many participants demonstrated a hybrid form of separation and integration of their professional identities by separating their possible selves from R&D science careers while maintaining a degree of connection to a science-based organisation or to the transferable skills

which a science education had inculcated. This is a bold step, as a conventional perception of a science career is predominantly in the R&D scope of work. For example, a few participants who retained a conventional perspective of science careers commented that their peers who had graduated with a science degree and eventually worked in a different field (e. g. as a property agent, insurance agent, or marketing executive) had *"wasted their three years"*; "*it's pointless that a science student ends up working in the marketing department*".

Participants in applied science courses particularly sought non-research roles as marketing personnel in science-based organisations (e.g. food science, crop science, pharmaceutical companies) where they would meet clients and still be able to apply their scientific knowledge. Miriam, who had pursued a product development technology degree, explained her career decision to embark on marketing roles instead of being 'cooped' in the laboratory. To her, the value of a science education is not merely the scientific knowledge, but also the transferable skills such as critical thinking, problem-solving skills, and analytical abilities which will be relevant for any other industry or profession. As expressed by Melissa:

> *Some people asked me – you have studied science for so long, why don't you work in the area you studied… It's a waste, right? I said that I am not giving up on R&D, I just feel that it is not necessary for my knowledge in science to be restricted to R&D only.*

Gavin also preferred a marketing role in a business organisation, mainly because the salary is higher in business than for R&D roles, and he also noted that pursuing a science education provided training in various areas of soft skills. A salient self-awareness was noted in Gavin and Melissa in terms of how their personalities were more suited for marketing roles as they enjoyed meeting people. There is also an awakening amongst some graduates that the career possibilities for science graduates can be limitless, and not confined to R&D lab work as most science graduates are led to believe. This enlightening discovery appears to Kai Sim to be the most liberating and inspiring:

> *I went to this intervarsity seminar. The CEO from an established biotech company in Malaysia told us that it is not necessary that if you study science you need to go into a science career – you could become an entrepreneur. You can be anything you want. He was inspiring. So, from that day on, I stopped being so disappointed with myself.*

Entrepreneurship is a prominent theme that emerged from these narratives, demonstrating the desire of these students to make a difference in society through sustainability initiatives by combining knowledge from both science and commercial disciplines. Terence, who had had a negative internship experience which was irrelevant to his field of study, planned to embark on mushroom farming; while Ken, in the biotechnology field found a niche in the wastewater treatment industry. These two intended to collaborate with their peers from other university courses for their ventures. A notable pattern in the narratives seems to suggest that pure science undergraduates who embarked on academic research for their final year

project or who serve as a research assistant in a supportive environment, found a relatively stable path through their transition passage. Parvindra, in particular, was very certain of a research career for himself, as he said:

> *My lecturer told me, you really have to isolate yourself from the social world because research is not an 8 to 5 job. It's a 24-hour job. I experienced that during my final year research project which gave me an insight into how research is going to be. You need to find and read a lot of journal articles. And I find myself a research-oriented person.*

In many ways, a positive research training or internship experience in the final year, as well as nurturing future lecturers, plays an important role in shaping the professional identity of the pure science undergraduates.

DISCUSSION

This study seeks to understand the transitional process of professional identity construction and negotiation among final year science and engineering undergraduates as they navigate career crossroads in a developing nation and create new meaning for themselves. As Beijaard et al. (2004) suggested, identity is a process of being and becoming, and responding to questions about 'who I am' at this moment, and 'who I will become'. Within this process of professional identity construction and negotiation; personal, interpersonal, and institutional factors play a vital role in shaping students' experience and their perception of STEM careers (Wei et al., 2021). Professional identity in this study is seen as an ongoing process of separating and integrating the 'personal' and the 'professional' aspects of self, as one attempts to deal with the tensions between agency (personal dimension), social structures (cultural values and norms) and contextual landscape (labour market/workplace demands). Adapting from the university student transition framework proposed by Gale and Parker (2014), the narratives from the participants of this study are aggregated and contextualised to construct a typology of STEM professional identity transition (See Table 2).

Table 2. *A Typology of STEM Professional Identity Transition*

Conceptions of Student Transition	Themes of Professional Identity Transition	Salient Identity Transition Period	Symbolic Rituals of STEM Passage
Transition as Induction	The Birth of STEM Identity	Late Primary/Early secondary school	Enacting professional identity based on curiosity and fascination with science via: • Scientific competitions • Scientific magazines • Experiential learning activities • Informal experiments at home • English language as medium of teaching/learning • Role models
Transition as Development	Set Apart for Success	Mid secondary school/ Pre-university level	Establishing identity based on academic competence, intelligence and hard work via : • Excellent results at middle-high school public examination • Enrolment in science stream/elite science academy • Scholarships received based on merit and course pursuit that aligns to industry needs
Transition as Negotiation	Liminal Space in STEM Careers	Early-mid phases of undergraduate degree pursuit	• Defending identities based on nobility of science (pure science) relative to other professional paths in university course selection • Balancing identities based on work life balance consideration in dealing with course demands • Rethinking identities based on job prospects (including gender discrimination) and expected salary during internship experiences and career fairs
Transition as Reconstruction	Redefining STEM Career Boundaries and Trajectories	Final year of undergraduate degree pursuit	• Renewing identities based on scientific transferable skills in business job roles and science-based entrepreneurial endeavours • Affirming identities based on the relevance of personality and work-life priorities in teaching/business roles • Securing identities in research competence and contribution to society via further studies (eg. Master and PhD)

The overarching theme of ‘Transition as Induction’ refers to the genesis of STEM professional identity formation which is most instrumental during the earlier phase of high school education, through experiential educational experiences in STEM, family influences, and through passionate teachers and lecturers who are role models. The concentrated enrichment programmes to encourage STEM aspirations during students’ formative years are important, since students who, by the age of fourteen, have a clear-cut goal to have science-related careers are three and a half times more likely to graduate with a STEM degree (Tai et al., 2006). In a similar vein, Bada and Jita (2022) underscored the importance of collaborative learning that is meaningful and synergistic to promote student success in science education. More importantly, the positive emotions developed from these encounters are deep-rooted and enduring, creating an aspiration in participants to pursue a career in science retained from high school to tertiary education.

An unexpected finding of this study highlights the critical role of the English language as the medium of instruction for teaching and learning science in Malaysia. The use of English in learning and teaching science (which was replaced with the native language in 2009), was noted in this study, as an enabling mechanism towards an appreciation of STEM. The findings also showcase ‘Transition as Development’, as the identity of a ‘science’ student is validated through the streaming process based on the lower secondary examination results. As expected for a collective society such as Malaysia, strong coherence of personal and social identity is evident at this phase of life. A successful outcome in the public examination at middle high school warranted an exclusive path towards promising STEM careers, with a merit-based, streamed education system. Furthermore, science students are socially perceived as ‘good’, 'smart', and 'hardworking', and they develop their professional identities through continued excellence in their high school examinations and securing scholarships in the pre-university studies.

While all participants in our study shared a relatively common journey of STEM identity construction at childhood and adolescent phase of life, with meaning educational experiences and inspiring teachers as the main catalysts for STEM pursuits, there were variations in how individuals negotiated their identities in STEM during the liminal period. We conceive ‘Transition as Negotiation’ as an overarching theme as participants experience the trade-offs as a science undergraduate and worst/best career outcomes in their perceived future selves. While certain individuals in the pure science degree had to defend their STEM identities against ethnic cultural norms to pursue a higher status profession such as a law or medical degree, others may experience cognitive dissonance in their choice of career path. The higher education experience seemed to be a defining factor as to whether these future workforce members would remain in, or leave R&D scientific careers. The heavy course demands, unfavourable experiences during their internship and the perceived lack of career opportunities upon graduation were major deterrent factors. A professional identity in science at this juncture was commonly defined with phrases such as ‘poorly paid worker’, ‘work long hours’, ‘no personal life’ which are highly demotivating when compared to positions in the business sector. These multi-faceted

considerations compel the science undergraduates in 'balancing' their identities while remaining true to the scientific field, and/or rethinking their identities by exploring possible future selves.

Towards the final year of tertiary studies, 'Transition as Reconstruction' depicts how science undergraduates begin to imagine a renewed identity which is empowered by the integration of a multidisciplinary career pursuit. As observed by Schawbel (2014), this generation is adept in adapting an entrepreneurial identity by integrating science and business in sustainability initiatives through collaborative efforts with peers. There were participants especially in the applied science courses, who would not hesitate to explore a more lucrative banking profession that welcomes science graduates for their analytical, rigorous, and critical thinking abilities, or a teaching career that allows them greater autonomy and work-life balance opportunities. In line with a report regarding 'Generation Z' work trends (Fratričová & Kirchmayer, 2018), this study finds that the contemporary science and engineering students tend to view their career as a course for exploring their passion; extending their professional identities while obtaining fulfilment and work-life balance. This evidence complements the findings of Kelly et al. (2020) quantitative study that noted a non-significant difference in the status of STEM professional identity for both students and professionals in the workforce, with a very low number of participants who demonstrate a strong commitment to a STEM career. This ongoing explorative status of STEM professionals is seen to be a significant feature in a portfolio career landscape characterised by a merging of STEM and business professions which render the traditional demarcation of specialised disciplinary practice less relevant.

From a renewed rites of passage perspective, this study also highlights the reality of how we need to be 'comfortable' with liminality as a journey of incremental self-awareness while the state of 'reincorporation' into the society (or STEM community) is subjected to individual interpretation and can be momentary as changes in life stages refashions one's adjustment in time and space. The narratives in this study illustrate how science and engineering undergraduates travel through the higher education terrain with dreams and dilemma, while exhibiting authorship by redefining STEM career boundaries and trajectories that give birth to renewed identities in some individuals, while affirming or securing identities in others. This is consistent with the career construction theory which sees vocational pursuits as stories which serve as a means of articulating the tensions that arise as individuals negotiate the transition from one life chapter to another, or between one role to another (Dix, 2020). These narratives extend one's educational experiences into vocational sense-making that enable changed behaviours, courageous vocational decisions and/or unwavering fidelity in one's initial choices in STEM careers. Contrary to the 'traditional' view of rite of passage that focuses upon the re-incorporation of individuals into social group or community as the 'final phase' of reintegration with their new identities, we posit that in a contemporary setting, science undergraduates experience 'transition as reconstruction' instead of reincorporation, as they reimagine new possibilities and identities that may or may not confine within a typical scientific future self.

More importantly, this process of reconstruction is an enabling platform for developing resilience and meaning-making in the face of changing professional landscape in the 21st century that centres on diversity and multidisciplinary endeavours.

IMPLICATIONS AND CONCLUSION

The Covid-19 pandemic has resulted in a 'great reset', after which we are compelled to collectively reimagine a new future for the new entrants into the STEM labour force. While it is important for policymakers and researchers to encourage an upward trend towards the enrolment and completion of undergraduates in STEM courses, our findings highlight the complex interplay of social, cultural and structural factors that impact students' entry, development, and persistence towards a science career in a developing nation. Also, the value and benefits of using English as a medium of instruction in teaching and learning science in high school deserve due consideration, particularly when Malaysia has reverted to the practice of using the national language as the medium of instruction while allowing some schools with the necessary resources to operate on a dual language model.

More importantly, our study calls for a re-conceptualisation of what a 'science' career entails in a developing world context. Rather than confining the science education system to R&D careers or professional engineering careers, perhaps we need to have an expansive view of science careers to include non-traditional roles that support the scientific industry or innovation ecosystem. According to Takeuchi et al. (2020), there has been an over-reliance on science education in defining and situating what should count as STEM education, which can severely limit our imagination for the design of STEM education. In tandem with the changing societal landscape and sustainability agenda in solving complex problems such as climate change, waste management, poverty reduction; a holistic multidisciplinary approach empowered by design thinking capabilities, reflections, and empathy will be the way forward in preparing future generations (Goldman & Kabayadondo, 2017; Sung & Choi, 2022).

The internship programs undertaken by final year undergraduates also deserve serious attention as these encounters contribute towards the formation of their impression of science careers and hence, their decisions about future career paths. Aligned to Maertz et al. (2014)'s observations, students may not be satisfied with the internship experience because of unchallenging, scattered, career irrelevant tasks and unhealthy workplace culture which results in negative perceptions or doubts about their future careers in the discipline pursued. A strong partnership is needed between the universities and corporations to ensure that mental and emotional support is provided, and meaningful learning experiences take place during this period of internship engagement. Conscious efforts are necessary to provide sustained professional development and career opportunities for STEM graduates in the government or corporate sector, particularly for the high-performing graduates who are identified as STEM talents in the workforce.

Due to the nature of our narrative inquiry, the sample size for this study was relatively small and confined to the narratives of a specific group of science undergraduates in Malaysia. Complementary research may need to be undertaken, such as a longitudinal study involving surveys of a larger sample population to track the experiences of STEM final year undergraduates, especially the high achievers or scholars under the sponsorship of government agencies, throughout their first few years of work, to assess their professional identity construction and negotiation over time. A holistic understanding of students' experiences and professional identities in STEM will be useful in informing STEM education and a new policy agenda aimed at promoting well-being among STEM undergraduates as they track the boundaries and terrains of the contemporary career landscape.

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