



# The entrepreneurship skills that biotechnology graduates need: findings from entrepreneurial employees in a developing economy

Abdul Afif Ahmad Aziz<sup>1</sup> · Susan Rowland<sup>1</sup> 

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## Abstract

Biotechnology is a focus for many developing countries, but educators are grappling with the problem of how to prepare graduates for entrepreneurial biotechnology employment in these environments. This study addresses this problem by examining entrepreneurship and entrepreneurship skills from the perspective of employees in the Malaysian biotechnology industry. Twelve biotechnology and science graduates who work for biotechnology-related industry and academic employers in Malaysia were interviewed. We asked how they define entrepreneurship and what entrepreneurship skills best support their work and their identification of entrepreneurial opportunities. The employees had a multi-faceted understanding of how they work entrepreneurially within their organizations, and they identified multiple skills and attributes that contribute to their entrepreneurial activity. This pilot study provides new information about the entrepreneurship skills that biotechnology employees see as valuable for their work in the service of their employing organizations. As a result, educators will be better able to design entrepreneurship training programs in science and biotechnology that are relevant to graduate employment needs. Although Malaysia, a developing economy, is used as a context for the study, this work has broader implications. We anticipate these findings will be useful for educators and policymakers worldwide who have an interest in designing and delivering biotechnology entrepreneurial learning programs that help students prepare for employment.

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✉ Susan Rowland  
s.rowland1@uq.edu.au

<sup>1</sup> School of Chemistry and Molecular Biosciences, The University of Queensland, St Lucia, QLD 4072, Australia

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## Introduction

Biotechnology is big business. Despite a recent downturn in growth rate, the biotechnology industry is still an economic engine that generates massive revenues and employs people on a huge scale. During 2016, overall revenue of publicly traded US and European biotechnology companies reached a record-high US\$139.4 billion, and these same companies employed more than 200,000 people (EY 2017, p. 32). This is not, however, the extent of the biotechnology industry. Governments, universities, start-up companies, and publicly listed companies outside the USA and Europe also work in the biotechnology space; in countries like Brazil, China, India and Malaysia, there is increasing investment in and attention toward the biotech sector (Bonalume Neto 2010; Jayraman 2016; Academic of Science Malaysia 2015; Rezaie et al. 2012). The worldwide biotechnology push creates a need for STEM employees who have appropriate skills (Bioeconomy Corporation 2018a), one of which is entrepreneurship.

In the last several decades, numerous studies have been done around integrating entrepreneurship learning into tertiary education (Gartner and Vesper 1994; Katz 2003; Miller 1987; Pittaway and Cope 2007; Sánchez 2013). There is only a limited number of studies that address entrepreneurship education in life science and biotechnology (Collet and Wyatt 2005; Heinonen et al. 2007; Mitchell and McKeown 2004; Souitaris et al. 2007), and entrepreneurship education has only recently received attention for its importance in the areas of science, technology, engineering, and mathematics (STEM) (Spike Innovation 2015).

Most of the studies just referenced focus on the impact that entrepreneurship education has on creating entrepreneurial intent, or the intention to “pursue an opportunity” (Valliere 2017, p 60) in the business space. Entrepreneurial intent is a common lens for the study of entrepreneurship education, but our research interest is in employability. Thus, this study takes a different approach and examines the skills needed for entrepreneurship by employees in the biotechnology sector in a developing country. As indicated by Shane and Venkataraman (2000), there is space for company employees to be entrepreneurial, as they can recognize opportunity and exploit it for the benefit of their company or organization.

The purpose of this study is to uncover the entrepreneurial skills that Malaysian biotechnology sector employees use in their work. This information will allow educators to design educational programs that help students obtain entrepreneurship skills that are valuable in biotechnology employment. This study may also help identify entrepreneurial skills that can contribute to the growth of the biotechnology industry in Malaysia and other developing economies.

## Research questions

We conducted a qualitative, empirical study with 12 Malaysian biotechnology sector employees using semi-structured in-depth interviews and an inductive coding method.

We asked three research questions:

1. What is the definition of entrepreneurship that these employees hold?
2. What are the essential entrepreneurial skills that support the work of these employees in the Malaysian biotechnology industry?
3. How do these employees identify and decide to exploit opportunities in their line of work?

Question 2 is the core research question for the study. We asked Question 1 to contextualize the participants' responses to Question 2. Question 3 gave additional richness to the Question 2 responses, as it encouraged participants to answer questions using a focused and specific conception of entrepreneurship.

We expect this work will provide value to current biotechnology and science students (who are the future employees or employers in the Malaysian biotechnology sector) and educators who design and deliver biotechnology and science entrepreneurship programs. This work also enriches our understanding of the ways in which science and biotechnology graduates practice entrepreneurship in the service of their employing organization.

## Theoretical background

The research history of entrepreneurship reflects its dynamic nature, complexity, and growth as a field. Scholars have promulgated multiple different views and definitions of the word “entrepreneur” and “entrepreneurship,” and the description of the terms depends on the lens used by the theorist (Davidson 2004; Filion 2011; Hill and Levenhagen 1995; Hisrich et al. 2002).

The word entrepreneur is of French derivation. It literally means “in between taker,” a person who makes profits by becoming the intermediate facilitator between the supplier and the market (Hindle and Yencken 2004). Entrepreneurs have been variously conceptualized as risk takers (Cantillon 1755; Knight 1921; Say 1817), capitalists (Marshall 1890; Ricardo 1817; Smith 1776), innovators (Schumpeter 1911/1934; Von Thunen 1966), alert opportunity seekers (Hayek 1945; Kirzner 1973; von Mises 1949), and coordinators of limited resources (Casson 1982; Say 1817). Despite the varieties of definitions of “the entrepreneur,” there is a consensus view that the entrepreneur is someone who undertakes the entrepreneurship process.

In a meta-analysis of entrepreneurship, Ahmad and Seymour (2008) recognized three key definitions of entrepreneurship activity. These are: (1) the creation of innovative products and markets through transformation of resources (Drucker 1985;

Schumpeter 1911/1934); (2) the emergence and development of new firms (Lumpkin and Dess 1996); and (3) the pursuit of opportunity through risk taking and alertness to asymmetric information (Kirzner 1973; Shane and Venkataraman 2000).

Only one of these definitions relies on the idea that an entrepreneur is involved in developing a new company. The other two suggest that an entrepreneur can work in their environment to try new things, recognize opportunities, and serve new markets. This type of innovative activity, within an established organization, is known as “intrapreneurship” (Pinchot 1985; Souder 1981). Intrapreneurship may result in the formation of a new organization; however, it can also generate new administrative techniques or strategies, newly competitive attitudes, and new products, services or technologies (Antoncic and Hisrich 2001). de Jong and Wennekers (2008) provide a comprehensive listing of intrapreneurial activities and behavioral attributes. The activities include “opportunity perception, idea generation, designing a new product or another recombination of resources, internal coalition building, persuading the management, resource acquisition, planning and organizing” (p. 2). They describe the core behavioral aspects of intrapreneurship as “personal initiative, active information search[ing], out of the box thinking, voicing, championing, taking charge, finding a way, and some degree of risk taking” (p. 2). Importantly, to perform in an entrepreneurial way, a person must also have entrepreneurial intention (Ajzen 2002; Krueger and Carsrud 1993; Kolvereid and Isaksen 2006; Pillis and Reardon 2007).

These ideas about intrapreneurship are highly relevant to our study, as we are asking employees in the Malaysian biotechnology sector about the entrepreneurial skills that best support their work. In this case, the subjects of the study are not focused on creating new businesses, but instead are using entrepreneurial (and intrapreneurial) behavior to value-add to their employer’s mission. Thus, it is important to frame our study, and to define entrepreneurship, using this lens.

In considering our definition of entrepreneurship, we also draw on the work of Hindle and Yencken (2004) who see entrepreneurs as people who are “making it happen”—they elaborate by saying “the entrepreneur can be seen as a creator: one who turns a potential exchange into an actual exchange, one without whom the transaction may never occur” (p. 795). From the perspective on an employer, then, it is possible to see the entrepreneurial employee as a person who recognizes and capitalizes upon opportunities that benefit the employing organization.

We have selected the work of Shane and Venkataraman (2000) to facilitate our work addressing Research Question 3 around opportunity recognition. Shane and Venkataraman (2000) define the field of entrepreneurship study as “the scholarly examination of how, by whom, and with what effects opportunities to create future goods and services are discovered, evaluated, and exploited” (p. 218). Importantly for our study, Shane and Venkataraman’s concept of entrepreneurship goes beyond the process of venture creation. It is sympathetic to the possibility that an employee can be an entrepreneur (or an intrapreneur) as they work for a larger organization.

Shane and Venkataraman (2000) divide the process of opportunity recognition into three parts: the existence of opportunity; the identification and evaluation of opportunity; and the mode of exploiting the opportunity. They suggest that to discover opportunity, an individual has to attain information, some of which may trigger conjecture that leads to opportunity awareness. The participation cost and the

duration of an opportunity may significantly affect its appeal; for example, patent protection may delay the beginning of opportunity exploitation. Consideration of ends–means relationships and risk also impact on opportunity evaluation. As stated by the authors, not every individual has the same perspective, which results in some individuals (and not others) discovering the opportunity. The nature of the opportunity may also influence the willingness of individual to exploit it. This is likely to be linked to the relationship of the opportunity to the individual’s self-interest and personal moral framework. It should be noted that our study is not an attempt to validate Shane and Venkataraman’s framework. In addition, we will not enter the interviews with a restricted conception of the term “opportunity” or the idea that an “opportunity” only exists when there is a possible financial gain.

Although we are using a broad definition of “entrepreneur,” we also acknowledge that much work has been done already to define the skills, characteristics, and behaviors of entrepreneurs. Past authors have used several lenses to examine entrepreneurs, and Filion’s (2011) meta-analysis of the entrepreneurship literature condensed this work into a list of activities and characteristics attributed to entrepreneurs (Table 1). After we examine the responses of the participants, we will compare their insights to these activities and characteristics.

**Table 1** Activities and characteristics often attributed to entrepreneurs (from Filion 2011)

Activities	Characteristics
Learning	Experience of a sector; memorized information; use of feedback
Choosing a sector	Interest; motivation; assessment of potential added value for the future
Identifying a niche	Care; analytical capacities; precision; targeting of effort
Recognizing and developing an entrepreneurial opportunity	Originality; differentiation; creativity; intuition; initiative; culture that values innovation
Visualizing projectively	Ability to dream realistically; conceptual skills; systemic thinking; anticipation; foresight; ability to set goals and objectives; visioning
Managing risk	Thriftiness; security; conservatism; moderate risk taking; ability to tolerate uncertainty and ambiguity; independence
Designing (products, services, organizations)	Imagination; problem-solving skills
Committing to action	Self-confidence related to clearly defined identity; long-term commitment; hard worker; energy; result orientation; decision-making capacity; passion; internal locus of control; determination; perseverance; tenacity
Using resources	Resourcefulness; coordination; control
Building relations systems	Networking skills; flexibility; empathy; listening and communication skills; use of mentors; vision
Managing—sales, negotiations, and people	Versatility; adaptability; capacity to design tasks; ability to trust
Developing	Leadership; seeks challenges

## Research stance and methodology

We take an open, interpretivist stance to the concepts of “entrepreneur,” “entrepreneurial activity,” and “opportunity,” because the study participants are employees of different types of biotechnology organizations, including government departments, universities, and more traditional market-focused companies. Packard (2017) argues that such an interpretivist approach to entrepreneurship allows for a robust, holistic approach to the concept, as it encompasses behaviors and attitudes that may not be specifically tied to a money-based market. Not all of the organizations that employ the student participants will be solely focused on profit; thus, it is appropriate to consider all of the ways in which these organizations, and their employees, conceptualize both entrepreneurship and opportunity. We also conceive of entrepreneurship as “a continually unfolding process, not necessarily tied to any specific outcome [...] but to the intentions and expectations of the entrepreneur” (Packard 2017).

When coding the participants’ responses, we will use a constructivist grounded theory approach (Charmaz 2006) to develop a picture of what entrepreneurial skills and activities “work” for employees in the biotechnology industry in Malaysia. This approach does not seek to find a single truth in the data. Instead, it addresses the truth that is developed (or constructed) individually through the interactions of people with their environment. Charmaz (2006) describes constructivist grounded theory as sitting “squarely in the interpretivist tradition” (p. 330). The interpretivist approach is generally attributed to Max Weber, whose concept of “*verstehen*” means “understanding something in its context” (Holloway 1997, p. 2). In our case, we are working to understand entrepreneurship in the context of employment in the biotechnology industry in a developing economy.

## Methods

### Sample selection and participant recruitment

A purposive non-random sampling approach was used to select participants using the following criteria for inclusion:

- undergraduate degree in biotechnology or a science- or engineering-related program;
- currently working for a biotechnology-related organization in Malaysia (e.g., tertiary-level education system, industry, or other biotechnology-related organizations);
- any duration of employment in the biotechnology industry, but a mixture of long-term and shorter-term employees is desirable;
- not running or owning their own business;
- not personally known to the study team;

a balance of genders if possible.

Potential participants were sourced and contacted through LinkedIn; search criteria reflected the criteria for inclusion. An introductory private message that briefly described the project was sent to 85 potential participants; 16 responded. These candidates received a formal invitation letter and other supporting ethics documents; 12 participants agreed to be involved, and ten were selected after screening using their demographic information.

At the same time, the BioNexus status companies list (Bioeconomy Corporation 2018b) was utilized to find potential interviewees in Malaysian biotechnology companies. We sent 153 emails to list members; two responded and nominated an employee for the study. Both nominees suited the study sampling criteria and were selected for interview.

This study was conducted in accordance with University of Queensland's Guidelines for Ethical Review of Research Involving Humans. All participants gave informed consent for their responses to be included in the study.

## Participants

The study participants come from a diverse education and working background. Participants completed undergraduate degrees in biotechnology ( $n=10$ ), science ( $n=1$ ), or engineering ( $n=1$ ) at Australian ( $n=5$ ) and Malaysian ( $n=7$ ) universities. Most participants hold postgraduate masters ( $n=7$ ) or Ph.D. ( $n=1$ ) degrees. Half the participants have worked in two or more biotechnology-related roles. Participants have worked as researchers, managers, marketers, and academics. The academics have work and teaching experience in the biotechnology industry. The demographics and work histories of the participants are shown in Online Resource 1.

## Interviews and transcription

Structured interviews (around 45 min each) were conducted via Skype and simultaneously audio-recorded.

The interview questions (Online Resource 2) explored:

1. the participants' understanding of entrepreneurship;
2. the entrepreneurship skills that participants used in their employee roles; and
3. the skills and processes that participants used to identify and evaluate opportunity in their work as employees.

Each participant was asked to submit an employment and educational history before the interviews; history details were confirmed during the interview. Transcripts of each interview were completed and then were sent via email to each participant for checking. After the transcripts were approved by the participants, they were used for analysis.

## Data analysis

We use thematic analysis to explore the interviews (Braun and Clarke 2014). Transcripts were uploaded to NVivo as sources and then inductively coded. For interview Qs 2, 3, and 5 (Online Resource 2), we coded inductively and then mapped the results to the framework of Filion (2011) (Table 1). For Qs 6 and 7, we also coded inductively, keeping in mind the definition of entrepreneurship from Shane and Venkataraman (2000). The inductive approach honors the terminology used by the participants, while the mapping links the findings to the larger entrepreneurship literature. We also tallied the scores from Qs 3 and 4 to provide a rank order for the skills.

Once all coding was completed by a single researcher, a second researcher re-coded all the transcripts using the inductively developed framework. Inter-coder reliability was checked using the Coding Comparison query function in NVivo. The Cohen's kappa for the 12 transcripts averaged 0.730, indicating "substantial" agreement across the framework (Landis and Koch 1977).

## Limitations of this research

This study focused on understanding the skills required for biotechnology or science-qualified entrepreneurs who were employed in the Malaysian biotechnology sector. As such, our results only apply to this group of people in this context. We do not claim broader applicability of the results. In addition, the sample size is small, despite our extended efforts to recruit a larger pool of participants. The participants are self-selected and were willing and able to participate in a research study. Consequently, we have not reached saturation in our sample or data collection (e.g., we were not able to interview people who worked for employers who did not approve of their participation). The results should be interpreted as an *indicative* but not a *definitive* picture of the opinions and experiences of the group under study.

## Results

### Malaysian biotechnology employees have a multi-faceted understanding of entrepreneurship; most see themselves as entrepreneurs

We initially investigated the ways in which each participant conceptualized entrepreneurship by asking them to define entrepreneurship. The coding framework derived from their responses is shown in Table 2.

The most commonly articulated understandings were:

1. entrepreneurship is creating something new or better in the form of products or services that are currently lacking in the market ( $n=7$ );



**Table 2** A summary of participants’ understandings of entrepreneurship

Theme	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Creating something new or better	X	–	–	–	X	–	X	–	X	X	X	X
Using financial or business acumen	–	–	X	X	X	–	–	X	–	–	X	–
Practically implementing something	–	–	–	X	–	X	–	X	X	X	–	–
Working as an intermediary	–	–	–	–	–	X	–	X	X	–	–	X
Strategically recognizing needs	–	X	–	–	–	–	–	–	–	–	X	–
Having a mindset to complete an initiative	X	–	–	–	–	–	–	–	X	–	–	X

2. entrepreneurship is exercising financial acumen (in which participants highlighted the importance of making sales or profit and being cost-effective) ( $n=5$ );
3. entrepreneurship is initiating and completing a practical implementation of some kind ( $n=5$ ); and
4. entrepreneurship is working as an intermediary between two components or parties ( $n=4$ ).

Importantly, only one participant limited their explanation of entrepreneurship to the concept of creating a new venture; the remainder implied or explicitly stated that there were other ways in which entrepreneurship could be exhibited and enacted. Some representative responses that include frequently coded themes are shown below; the participants are shown after each quote.

Entrepreneurship is - you have made your own innovation - it’s either goods or services that you are offering to the industry. The product or service must be novel and new, there must be a specialty in your product that no one else is offering. Then you need to market it to the industry. P10

[At my workplace] we are taking some project from external clients. Sometimes when we [my friends and I] discuss, we think maybe we should start up a company and give this kind of services because we are well versed with experiment we do and we know what consumables and how much it costs. P11

What I understand is no matter in what field, being an entrepreneur; you have to innovate something new or at least make something that already exists better. P7

P9 described entrepreneurship from her own perspective as an intermediary with a mindset to communicate clearly, broker relationships, and benefit the company: “I think it is some sort of like self-motivation—how you do your own work systematically and at the same time how you lead your colleagues—in my case, the lab assistant. As an intermediate between the management and the worker, how I manage and pass the message between the two groups—this is how I define entrepreneurship.

Also in my position how I contribute to the company's growth and how critical my position is in producing good services or products.”

P2 and P8 described entrepreneurship as a process of linking a good or service with a market in a financially responsible manner.

Anything in this world - whether it comes from the lab or anything; there must be sales for it, there must be [a way for it] to reach a community. The entrepreneurship plays a role in it. P8

I work in the marketing department, we construct and meet the brand strategy every year. We do market research and from there, we decide the best way to get consumers and to target consumers. After that we propose a brand strategy and conduct it throughout a year. P2

P1 was the only employee who did not appear to see herself as an entrepreneur. Instead, she described entrepreneurial behavior she saw in others and explained how she worked with entrepreneurial clients. “We interface with entrepreneurs on a daily basis. For me, an entrepreneur is somebody who has an idea and has the need or the want to drive that idea to fruition. Right from proof of concept to commercialization, all the way to marketing. Somebody who can do that, who has enough drive and passion to do that is somebody I would consider as an entrepreneur.”

Overall, most of the participants view entrepreneurship as a complex construct that extended beyond the idea of starting a new company or venture. Most also saw themselves as entrepreneurs within their organization. All the employees saw their employee role relating to entrepreneurship, and they articulated several different ways in which entrepreneurship manifested in their own work.

### **Malaysian biotechnology employees report using a range of entrepreneurial skills in their work**

We next focused on the skills that participants said supported their entrepreneurial activity as employees. The coding framework for these responses was developed inductively to reflect the full depth of the participants' perspectives and descriptions. We did not directly code the participants' responses under the headings used by Filion as would have required us to re-phrase the participants' words. The inductively derived coding framework allows us to honor the expression of participants who are working in English as a second (or even third) language. Table 3 shows a thematic analysis of the items the participants identified when asked about skills.

All the participants identified more than one item in their list of skills. Although we asked for “skills” (to make the question easy to address), the participants actually described knowledge (things they knew), skills (things they could do), and attributes (habits of mind or ways of being) in their answers. We made no attempt to correct them or enforce a distinction between the different categories of answers. In reporting the answers, we will refer to “skills,” but will point out the ways in which these answers may fall into the categories of knowledge and attributes as well.

A commonly and clearly articulated entrepreneurship skill was the ability to control costs. In some cases, this skill was discussed in terms of direct cost to the

**Table 3** Entrepreneurial skills that participants identified as supporting their work

Theme	No. of sources	Quotes
Communication	5	To do sales or business, one must have good communication skills
Cost control	4	If the cost is higher, then it will be a loss for our client
Critical thinking/analysis	4	Being analytical, comes a lot for being a science student, even though now we analyse market research data
Networking	3	...networking skill because without a good or proper network you wouldn't be able to have a good business
Interpersonal skills	3	Interpersonal skills, no matter how good a scientist or researcher you are...
Courage and risk for appetite	3	...the gut, the courage; only when you have the courage...
Customer and marketing knowledge	3	Knowing your customer—if you know your product but you don't know who to sell it to...
Ability to learn	3	Be a very resourceful person; read and be knowledgeable
Persistence/grit	3	...you won't be achieving what you want, but you shouldn't be losing confidence in between...
Negotiating	2	You need to convince people how your product will be valuable to them
Strategic planning	2	In the long run, strategic planning is the most important
Discipline	2	Discipline is crucial [...] in any field; without it you can't go very far
Problem solving	2	You must have a really good ability to solve any kind of problem that you're having during your business venture period
Creativity	1	Creativeness, but I rather call it craziness. One should be crazy enough to be an entrepreneur
Drive and passion	1	You need to be driven. That pushes everything else to happen
Initiative	1	If you don't have the initiative, you don't improve yourself
Flexibility	1	The client wanted to add something else. You have to be flexible
Persuasive skills	1	You need to convince people your product will be useful to them
Business skills	1	You need to have business skills; most science graduates don't
Leadership	1	...leadership; I'm trying to expose myself to the company...
Laboratory skills	1	Calculation, pipetting and troubleshooting. Calculation is most important
Quality control	1	Quality control—if we harvest override or unripe [plants], the factory will give us penalty

**Table 3** (continued)

Theme	No. of sources	Quotes
Responsibility	1	I think responsibility, taking responsibility
Interest	1	First of all you must be interested to do a certain kind of business

company. P5 stated they were “able to reduce the use of budget that was given for my department” and noted it was a skill that could “benefit your company.” P10 who worked across the academic/industry boundary described the process of developing a new product for their company, noting he looked for “materials that require low cost with higher value added.” In contrast, P3 worked for an organization that managed land; he noted that cost control was a key skill because “we need to tell the land owner how much money we used for each hectares of their field.” Statements like these indicate that the participants associated their entrepreneurship with financial benefits for their employing organizations, and with maintaining a functional business model. There is no direct correlate with this skill in the Filion (2011) model (Table 1). Perhaps, the closest parallel is to Filion’s ideas of “using resources” and “managing risk.”

There are several other “business” skills given in Table 3, including “customer and marketing knowledge,” “strategic planning,” “attention to detail,” and “quality control.” When the participants described these skills, they were likely to talk about them as ways to save money, identify sales opportunities, and recognize competitive products. These were the functional, nuts-and-bolts components of managing a business or organization that is active in the biotechnology marketplace. These ideas are closely akin to Filion’s statements about “choosing a sector,” “identifying a niche,” “visualizing projectively,” and “recognizing and developing an entrepreneurial opportunity.” Filion’s idea of “managing” may also fit here, but the link between the participants’ statements and Filion’s explanation of managing is only tenuous.

In his statement about landowners, P3 also touches on the need to communicate and use interpersonal skills. He elaborated on this idea later: “The top priority will be the human relations. We can communicate with the settlers so that we convince them to invest or pay more. Some of the agriculture inputs are a bit expensive, so without them investing more, we could limit the output of our yield. So for me the human relation is the most important.”

P7, a researcher, spoke about the need for communication and interpersonal skills within an organization: “As an employee or employer it is applicable to all of us to have good interpersonal skills. How you communicate helps to complete your project more efficiently. In a research team—doesn’t matter if it’s academic or business environment—anyhow you have to work in a team. If I don’t communicate with them and work alone, it will just not work.”

Several other responses addressed the need to communicate clearly, maintain relationships, navigate power structures, and explain the value of ideas and products; in Table 4, these are classed under “networking,” “negotiating,” and “persuasive skills.” These skills were frequently cited as a way to broaden the available market for an idea of innovation. P2, a saleswoman noted “to be able to bring the product to the market you need to have network first”, while P8 lamented the lack of market penetration from the academic perspective: “Being an academician, I can say a lot of things. The problem is that we are too theoretical. The content that we deliver does not reach people.” These ideas parallel Filion’s idea of “building relations systems.”

The participants’ responses also suggested that both emotional commitment and intellectual commitment are required for successful entrepreneurship. P1 identified courage as a key skill, saying that entrepreneurs “should be fearless.” She elaborated

**Table 4** Skills for identifying and evaluating opportunity that participants use in their work

Theme	No. of sources	Quotes
Seeking information	10	Based on the information that we gained from the market research then we decide whether we want to tackle the problem or not or how can we improvise...
Assessing return on investment	7	If the cost of production is high then it is not worth it to have that product instead use another product to tackle it
Interfacing with the work environment/ecosystem	7	You need to deal with the Government Ministry [and] you need to deal with community because you need to know the people
Meeting job responsibilities	6	one of the important things is the objectives of the company
Conducting a pilot/validation study	4	We started by doing the mechanism study and found a relevant source component from the plant so that we can substitute that with the current existing drug
Collaboration or purchasing of services	4	We are having mutual collaboration with universities
Problem recognition and solving	4	We look at the problems that we have currently at the moment and [ask] whether the products are there or not
Risk perception	4	Usually private companies, especially in Malaysia, don't take much risk [...]. They prefer if there is less investment to be done
Open mindedness and willingness to try new challenges	3	My supervisor said "Can you do this?". I said "I'll provide the protocol by tomorrow and the guideline by next week". I go and grab the opportunity—I go beyond what is asked from me
Drawing on one's educational background	3	As a scientist, you would like to know how accurate your data is
Intuition and personal interest	3	Yesterday we spoke to somebody—you can tell the guy is just faffing about, saying I want to open up a business but I don't know what it is going to be yet
Examining feasibility	2	Let's say you want to develop a mouthwash. Technically you can put the ingredient in, but regulatory wise you can't put all these ingredients together. The regulatory route will be too troublesome and take a long time to register the product
Trial and error	1	Yes, try and error (sic), because one product may work in one country but it may not work in another country

on this point, saying “I notice that a lot of entrepreneurs in Malaysia, who first start out are actually quite shy. I think it’s something that we need to start cultivating in our community—to not be afraid to ask questions because there is no such thing as asking the wrong questions.” P12 also described the need for bravery, saying “entrepreneurship—it’s not something easy ... you are starting something. You don’t know what’s the risk in the future.”

Additional statements from participants that address the need for personal investment in entrepreneurship are classed under “persistence,” “discipline,” “creativity,” “drive,” “initiative,” “flexibility,” “responsibility,” and “interest” in Table 3. These statements suggest that, to be an entrepreneur, a person must mentally and emotionally own the task at hand and commit to the entrepreneurial process. This approach to entrepreneurship is a way of being and a set of personal attributes that can also be seen as skills (if the person practices and masters the habits of mind and behavior). These observations closely parallel Filion’s ideas about “learning,” “committing to action,” “developing,” and “designing.”

When the participants were asked to rank the skills they identified, an aggregated ranking (Online Resource 3) shows that interpersonal skills and resourcefulness were ranked the highest overall, while courage, communication, and analytical critical thinking were ranked as the next most important. It is interesting to note the diversity in both the skills identified and the rankings given to these skills by the participants. This likely reflects the diversity of roles that the participants had in their employment. It also echoes and supports the diverse understanding of entrepreneurship that we saw in the literature review and the participants’ definitions.

### **Malaysian biotechnology employees report using a range of entrepreneurial skills to identify and evaluate opportunities; they foreground their employer’s mission and are acutely aware of cost/benefit calculations**

We next examined participants’ ideas about how they identify and evaluate opportunities in their line of work. Table 4 shows the inductively developed coding framework for this set of responses, with representative quotes.

Table 5 shows how many participants reported using each skill, with skill counts for each person. All participants used more than one skill to identify and assess entrepreneurial opportunities in their work. The median number of skills per participant was five. No participants described an opportunity recognition process that relied solely on formal methods they had learned from their university education. Instead, they described an organic approach to opportunity recognition and evaluation that combined multiple analytical and networking skills with a mindset that was open to new ideas.

Ten of the participants view seeking and assessing information as a process they used to identify and evaluate opportunities in their current employment, with market research or literature reviews being the main sources of this information. The participants indicated that they approached their work with the intent of finding an opportunity for entrepreneurial conjecture, rather than discovering the opportunity *de novo* and then considering the benefits of the opportunity as a subsequent step. We

**Table 5** Skills for identifying and evaluating opportunity that participants use (per participant)

Themes	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Seeking information	X	X	X	X	-	X	-	X	X	X	X	X
Assessing return on investment	-	X	X	X	X	-	X	-	X	X	-	-
Interfacing with the work environment/ecosystem	X	X	X	-	X	X	-	-	-	-	X	X
Meeting job responsibilities	X	X	X	-	-	-	X	-	X	-	X	-
Conducting a pilot/validation study	-	-	-	X	X	-	X	X	-	-	-	-
Collaboration or purchasing of services	-	X	-	X	X	-	-	-	-	-	-	X
Problem recognition and solving	X	X	X	-	-	-	-	X	-	-	-	-
Risk perception	X	X	-	-	X	-	-	-	-	-	X	-
Open mindedness and willingness to try new challenges	X	-	-	-	-	-	-	-	-	-	X	X
Drawing on one's education background	X	-	-	-	-	-	X	-	-	-	-	X
Intuition and personal interest	X	-	-	-	-	-	-	-	X	-	-	X
Examining feasibility	-	-	-	X	-	-	-	-	-	-	X	-
Trial and error	-	X	-	-	-	-	-	-	-	-	-	-
Total number/participant	8	8	5	5	5	2	4	3	4	2	6	6



hypothesize that this deliberate approach to opportunity recognition may reflect an awareness of the limited resources available in the developing Malaysian economy.

P8 and P10 provide two representative examples of this approach. P8, a researcher, said he decided on a research project “based on the statistics of the disease. I did a study. In entrepreneurship we call it a market study but from scientific point of view we call it a literature review. The current statistics produced by Malaysian Ministry directs (sic) me towards this research because arteriosclerosis is [a] leading killer in Malaysia.”

P10, an academic with an applied biotechnology research group, said: “I survey on the product or services that I would like to develop. For example if I were to develop a new supplement that has the benefit of increasing platelets in the body to fight against dengue, I would do a literature review and survey if there is such product in the market. If not, then I will try to develop it.”

Certainly, the majority of participants were keenly aware of the need to return on the investment associated with a chosen opportunity. Some described writing business cases, while others explained that they completed pilot experiments, commissioned initial work from another company or laboratory, or sought feedback through discussions with collaborators. P4, a manager, described doing “a business case to see whether will we get the return of investment from this product,” saying “We look at the market research to see whether we think this can work or not, and then to know whether we should pursue or not this opportunity we look at the commercial side.” P2 also stated “the return of investment is one of the important things.”

P1, also a manager, explained how she examined the risk associated with a potential venture partner: “The way we assess this [potential partner] is, we look and see their success rate in the past, what their work experience is. You can tell generally just from talking to them. You can tell by the way they structure their words and how in detail they talk about something and how passionate they are about it.” Although she appears to be working intuitively, P1 has a ten-year history of working in biotechnology, which likely allows her to bring her experience to bear on her decisions.

The connectedness of the participants to their co-workers, collaborators, larger community, and environment was evident in the responses coded under “interfacing with the work environment/ecosystem.” P3, a land manager, described proposing the development of, and then using an app to communicate with farmers; the app was important for identifying opportunities for improvement in the business. P5 described working with multiple collaborative partners on grant-funded projects. For P5, the collaborations meant his company gained access to “a lot of advance technologies.” He also attended conferences, where he harvested information from competitor companies to “start our own research.” P12 described a similar alertness to the opportunities presented by her academic environment, saying “I do observe what’s happening around me. Currently government policy is encouraging people to venture into agriculture so I think there’s an opportunity there.” P6, as a young sales representative, cultivated his network to gain access to “the top people in the organizational scale” because these people were key opinion leaders who could influence others to purchase his products. Responses like these indicate that connections to surrounding events and people are valuable sources and stimuli of new entrepreneurial opportunities.

The participants identified opportunities that were of interest to them, personally, but they also frequently described how they used their job responsibilities as a way to direct their recognition and assessment of entrepreneurial opportunities. They noted the need to focus on “the objectives of the company” (P4), saying “I follow instructions from my employer” (P9), and taking pleasure in the idea that “my supervisor was impressed” (P11). Importantly, four participants specifically noted that they identified opportunities in response to a problem they thought their employer could address; these problems included societal issues and communication difficulties with company clients. P4, who is a manager for a food manufacturing company, said “We like to have a large range of different products so that all kids will have a product that is specifically catered for them.” Responses like these show some participants were alert to ways in which their employer could help others. This type of social awareness makes good business sense, as it increases the likely market. It also may be that, in a developing economy, there are significant social needs that can be served by careful choices around which opportunity to pursue.

Only one participant (P2) said they used trial and error to identify or evaluate opportunities; importantly, they supplemented this method with multiple other mechanisms. Clearly, opportunity recognition and evaluation happens purposefully for the participants we spoke to. The participants’ responses suggest there is very little space in the Malaysian biotechnology industry to just “happen upon” an entrepreneurial opportunity and turn it into a profitable business venture using luck instead of good management.

## Conclusions and implications for educators

This study aimed to provide insight into the skills that biotechnology and science graduates need to support their work as entrepreneurial employees in the Malaysian biotechnology sector. Our results show that employees value business skills for their entrepreneurial work, and they also cite multiple personal qualities which contribute to successful entrepreneurial activity.

The participants talked about identifying an opportunity and building a business case through analysis of the market, conducting trials to obtain proof of concept data, and negotiating with their employer or other stakeholders to develop support for their initiative. This set of skills is very similar to the entrepreneurship curriculum proposed by McMullan and Long (1987), who suggested courses should be “structured around a series of strategic development challenges.” These challenges included opportunity identification, market feasibility analysis, new venture planning, obtaining new venture finance, and new market development. Although these challenges were defined by McMullan and Long for independent entrepreneurs, these are all things the study participants engaged with as part of their employment. This suggests that working as an entrepreneur as the developer of an independent business is a very similar process to working entrepreneurially within an existing organization.

Many of the personal qualities cited by the participants relate to risk taking, initiative, environment scanning, purposeful analysis of information, and a willingness

to self-teach. These are similar to the intrapreneurship activities defined and discussed earlier in this paper (de Jong and Wennekers 2008; Antoncic and Hisrich 2001; Pinchot 1985). They also speak to the entrepreneurial intent of the study participants.

In addition, the study participants adopted a service mentality in their entrepreneurship; many of their observations showed they used entrepreneurial activity to advance their employer's mission. Again, de Jong and Wennekers's (2008) ideas around intrapreneurs as people who build internal coalitions, persuade management, and "find a way" are relevant here. The findings from this study suggest that universities can provide useful, work-relevant entrepreneurship training in their biotechnology and science programs without explicitly training students how to start their own businesses.

The participants articulated multi-faceted conceptions of an entrepreneur and entrepreneurial behavior; almost all of them saw themselves as entrepreneurs within the context of their employment. Importantly, none of them saw entrepreneurship as an activity that exclusively involved the creation of a new company or personal business. From an educator's perspective, these findings show it is important to stress to students that entrepreneurial behavior is everywhere in the workforce. We should keep in mind that graduates need both entrepreneurial skills and an awareness of the importance of an entrepreneurial mindset in any employment situation. Both educators and students should remain open to the idea that entrepreneurship capacity is intimately linked to being a valued worker who innovates and value-adds in the service of the employer.

When the participants described the "skills" that supported their entrepreneurial activity as employees, they routinely described a mixture of business skills and personal attributes. From an educator perspective, these data show that, although knowledge about business practices is important to the employees, the capacity to draw on personal abilities to learn on the job, communicate, take risks, and persist in the face of difficulty is also crucial. As educators, we should nurture an entrepreneurial mindset in students by providing them with opportunities to develop and practice resilience, problem recognition, problem solving, communication, and negotiation capacities during their education.

When the participants explained how they identified and decided to exploit opportunities, it was clear that they considered the mission of their employer, the risks, and the payoffs of the potential opportunity. They also looked for community or client-related problems that their employer could help solve, and then sought information from a variety of sources to evaluate the resultant opportunity. These data suggest that a key way educators can prepare entrepreneurial employees is to help students consider the idea of service (to something larger than themselves) and the social value of entrepreneurship. This idea could be a very powerful motivator for new entrepreneurs. In a meta-analysis of the entrepreneurial intent literature, Schaegele and Koenig (2014) showed that the perceived desirability of entrepreneurship has the strongest direct effect on entrepreneurial intent. A person's values lead them to perceive entrepreneurship as desirable (Shapiro and Sokol 1982). Again, as educators, pointing out the social good that can stem from entrepreneurship may increase students' entrepreneurial intent.

How do we teach this broad conception of entrepreneurship, and the broad set of supporting skills, to biotechnology students? There are few precedents to help answer this question, as there are only a few reports in the literature about entrepreneurial educational programs in life science and biotechnology (Collet and Wyatt 2005; Heinonen et al. 2007; Mitchell and McKeown 2004; Souitaris et al. 2007). This small set of publications still, however, shows interesting trends in the student responses. It appears that extroverted, confident students who intend to start a business (or who see themselves as traditional entrepreneurs) tend to respond well to the reported programs. In contrast, students who are more retiring, or who do not envisage themselves as a business instigator, are more likely to find the programs overwhelming, frightening, or irrelevant. Heinonen et al. (2007) even quote a student who found the entrepreneurship program too demanding because the student did not want to start their own company. The student said “My goals are linked to the fact that I want to find an interesting job in an existing life-science company.”

Certainly, there appear to be difficulties in teaching entrepreneurship to life science and biotechnology students, especially if teaching takes the perspective that entrepreneurship is only “about” starting and running a new business. Data from Maresch et al. (2016) show that science students tend to believe their family and friends would not support their entrepreneurial activity (in terms of starting a venture), while business students believe the opposite. Maresch et al. (2016) suggest, in response, that “educators should investigate whether they can create entrepreneurial education didactics that tap into the cognitive schemata of science [...] students” (p. 177).

Maresch and co-authors do not elaborate on the schemata they believe science students would find acceptable and, again, there is little in the literature to enlighten us in this space. We can fall back, however, on the commonly held belief that students (and young people generally) are idealistic and they want to make a positive change in their community. Essentially, they are comfortable seeing themselves as social entrepreneurs (Abu-Saifan 2012; Halberstadt and Kraus 2016) who enact social change through their enterprise (Zhang 2017). Governments (DIIS 2018) and organizations (VFA 2018; YBI 2018) recognize the force of this youthful goodwill, and they specifically support young people’s entrepreneurial efforts to channel their energy and ideas into useful work for society. It makes sense for educators to also connect science students with entrepreneurship by highlighting the positive social aspects of the practice, especially if students come from a country with a developing economy.

The modern understanding of entrepreneurship posits that ideas and entrepreneurial drive underpin all human activities (Halberstadt and Kraus 2016). These ideas are consistent with the diverse and consistent entrepreneurial behaviors and activities reported by the participants in our study. It may not be easy to explain to biotechnology students how they can all be entrepreneurs. Traditional conceptions of the entrepreneur as businessperson can be strongly held, even in the face of organizational messaging and carefully designed curriculum components (Zhang 2017). Still, we believe the evidence from this study gives weight to the idea that everyone can be an entrepreneur while still being an employee. Certainly, entrepreneurial work requires some business-related skills. As educators, however, we can use the statements from

the study participants to help students understand that they do not need to start and run their own business in order to be an entrepreneur. Instead, entrepreneurial work in science and biotechnology is about considering growth opportunities for oneself, for the community, and for one's employer. The participants in this study showed us that this behavior is important for employees in a developing biotechnology industry like Malaysia. We suggest, however, that the lessons learned from these participants are applicable for entrepreneurial biotechnology employees across the world.

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