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## *Original Paper*

# Enhancing Entrepreneurial Intent and Self-Efficacy in Women Life Scientists via Virtual Simulation Research

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### **Abstract**

Few life science businesses are started by women despite nearly half of life science graduate students being women. To increase early career women life scientists' interest and intent in starting a business, we developed and evaluated an online program featuring interactive simulations. To develop the simulation narrative, we identified common entrepreneurship needs of women scientists using literature review, surveys, and focus groups. The common needs we identified included the need for strong networks of support and mentoring, effective communication skills, and better understanding of business, finance, and available resources. To address those needs, we presented an introductory, experiential, narrative overview of starting a business with characters based on real life women who overcame barriers to entrepreneurship. Through the simulations, we aimed to increase the scientists' awareness of rewarding aspects of entrepreneurship, understanding of what is involved, basic skills needed in the initial phases, and business-related confidence. We evaluated the completed product with a diverse group of 28 women life scientists. After using the program, most of them (>85%) reported an increased intention to engage in activities that help entrepreneurs get started, including doing more networking, seeking mentors, and participating in life sciences organizations for women. Around a quarter of participants (27.3 %) said they were more likely to start a business someday after completing the program.

**Keywords:** entrepreneurship, life science, simulation, women

### **1. Introduction**

This paper describes the development and evaluation of online simulations and a website designed to help increase entrepreneurship by women life scientists. The simulations and website, BioStartupAdvice.com, represent the culmination of three years of research, writing, and technological development by Clinical Tools, Inc. (CTI), creators of immersive online training for clinicians and scientists.

#### *1.1 The problem*

Few life science startups are founded by women, despite women comprising nearly half (48%) of graduate students in the life sciences (Fry et al., 2021). Only around 16% of tech startups in North America are founded by women (Stefanuto, 2023). Women comprise only around 14% of inventors listed in global patent applications, suggesting that women scientists translate their ideas into businesses less frequently (Elsevier, 2017).

Women are under-represented in entrepreneurship in general. Men outnumber women 3 to 1 in owning businesses worldwide (Masterson, 2022). In academia in the UK, only 13% of spinout companies have at least one woman founder (Griffiths & Humbert, 2019).

The gender discrepancy is even greater with respect to obtaining venture capital (VC) (Hathaway, 2019). Startups led by women receive only a small fraction of total funding (Pitchbook, 2023). Women-led companies that do attract funding generally obtain less funding than companies led by men.

Men are twice as likely to raise \$100,000 or more in funding (Kanze, 2021).

Under-representation of women in the life sciences industry limits the diversity of ideas, wastes intellectual capital, and results in ideas for products and solutions not being brought to the market (Vicaria, 2023). Increasing the number of women scientists starting businesses could increase the number of businesses translating scientific discoveries into improved health and other aspects of life and contribute jobs and other economic value. Further, gender diversity in businesses is associated with superior value and greater profitability (Krivkovich, 2017).

There are still many barriers in industry, academia, and society that contribute to women starting businesses less frequently than men, including women having:

- Fewer same-gender role models for going from academics to business (Swain, 2020).
- Less confidence in business situations than men, on average (Mohr, 2014; HM Treasury, 2023) and less experience than men, on average, when starting a business (Kanze et al., 2018). Women frequently underestimate their skills and potential for success (Kanze, 2021; Vidadieva, 2024), fail to advocate for themselves (SlateCustom, 2015), dismiss their own achievements, and give others credit for their success (HM Treasury, 2023).
- Fewer opportunities for business growth and success due to gender bias and stereotypes (Vicaria, 2023). Many people are still less likely to engage with a business that is woman-owned (Vidadieva, 2024).
- More of a challenge balancing family care with the demands of a startup due to more time on family caregiving on average (Vicaria, 2023; Kanze, 2021). Challenges include inflexible work arrangements regarding time off needed for child care (Vicaria, 2023).
- Less involvement in business networks (Vidadieva, 2024), resulting in fewer opportunities to grow their business; build relationships, and locate clients, partners, and suppliers (Vidadieva, 2024).

Women's businesses get far less VC investment money and as a result, are less successful on average. Although 40% of US startups are founded by women (Kanze et al., 2018), only 2.1% of the VC goes to businesses with all female founders (PitchBook, 2023) and women receive an average of \$1 million less than men-owned startups (Srinivas, 2021). Conscious and unconscious gender bias contributes (Mass Challenge, 2023), both against women-owned businesses (Kanze et al., 2018) and in favor of male-owned businesses (Hathaway, 2019). Further, women on average have less access to funding (Vicaria, 2023), ask for less money (Swain, 2020), and have less confidence (Mass Challenge, 2023). Investors are often deterred by CV gaps from time off taken for childcare (Swain, 2020).

### *1.2 What is needed to address the problem*

Life scientists starting a business typically need to learn essential business skills. Successful entrepreneurship requires awareness of best approaches, resources, available support, confidence to overcome barriers, and skills to avoid common mistakes. However, women often encounter additional barriers, such as funding bias, male-dominated networks in biotechnology and venture capital, and having few women role models.

From the lists we gathered of challenges that women entrepreneurs face, we developed a list of needs we could try to meet via an online simulation and supportive content. These include a basic understanding of what is involved in starting a business, the life impact it might have, encouragement to consider forming a startup, and skills and support to succeed and help them overcome systemic barriers they might encounter as women in the life science industry and entrepreneurship in particular. The needs we selected to address are described together with our interventions in the Methods section.

## **2. Method**

### *2.1 Program (Intervention)*

We focused the intervention on early career women because women start only a small percentage of life science businesses but comprise nearly half of life science graduate (Fry et al., 2021). Participants in our needs analysis also recommended targeting early career scientists. We also chose to target

scientists with minimal entrepreneurial interest, knowledge, or confidence in starting a business because these are factors we could attempt to influence via inspirational stories told by role models of successful women entrepreneurs. While we focused the evaluation on graduate students, the full target audience included all early-career life scientists or life science entrepreneurs. We chose to develop game-like simulations to engage our young adult target audience. People between ages 18 and 34 are the group that plays video games the most and nearly half of gamers are women (Jovanovic, 2023).

The simulations aim to increase women life scientists' awareness of entrepreneurship as a potentially rewarding career option, improve their understanding of what it would take to successfully start a business, and increase their self-confidence, interest, and intention related to starting a business. The goal is to inspire scientists to consider entrepreneurship as a career path and create a resource that can continue to support scientists in the early stages of founding a business.

We focused on addressing barriers and other needs and interests of individual women scientists by improving their knowledge, skills, awareness of resources, and awareness of approaches that have been effective for others. We acknowledge we cannot address the more systemic problems in an intervention for individual scientists other than to make scientists aware of systemic problems and to encourage networking and collective action.

We conducted a literature review and needs analysis via surveys and focus groups to identify reasons women life scientists start fewer businesses and developed an online program to impact those reasons through education and motivation. The program aimed to support women in overcoming obstacles, which included the need for strong networks of support and decreasing any risk aversion through increased knowledge of business and finance, and available resources. The program presents an introductory, experiential overview of entrepreneurship via the simulations and provides links to brief articles on the accompanying website, BioStartupAdvice.com, to allow users to dive deeper into areas of interest. The basics covered include the steps to launch a business, intellectual property, funding, and communication skills. The program aims to help life scientists gain confidence that they could pursue business ideas as they navigate realistic scenarios and learn about real-world resources.

The components of the program, all available on the website are. . .

- Simulations and case stories
- Introductory-level information in key point summaries and links to read more on topics of interest
- Interactive quizzes and self-check surveys
- Curated and annotated external resources

The simulations utilize fictional characters created in a 3 dimensional environment. The characters are based on real-life women scientists to help early career women scientists explore the possibility of entrepreneurship as a career option. The simulations tell stories of women overcoming obstacles and facing risks commonly encountered in entrepreneurship. We deliver key tips and advice via simulated female entrepreneurs who we designed to act as role models.

In the first simulation, "Day in a Life," users navigate a biotechnology business where they experience a day in the life of an early career, woman life scientist who talks with coworkers about starting a life science business. See Figure 1. At the end of the day, she learns more about entrepreneurship by talking with a group of colleagues and successful entrepreneurs during a networking event at a local biotechnology support center.



Figure 1. Lab in “Day in a Life” simulation

The second simulation, “Steps to a Startup,” illustrates the steps to starting a business, supplemented by key points, self-check surveys, interactive challenges, and brief articles on early entrepreneurship. Figure 2 shows several women entrepreneur characters from the “Steps to a Startup” simulation.

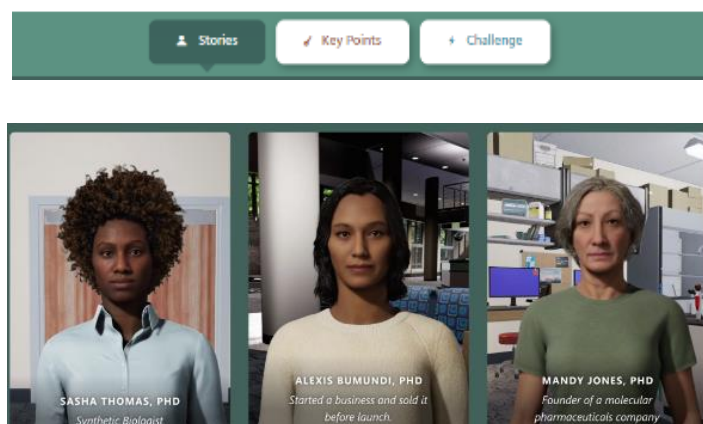


Figure 2: “Steps to a Startup” simulation: Case examples

The skills and knowledge we targeted in these simulations included. . .

- Communication skills including networking, advocating for themselves and each other, using an assertive style, pitching ideas, and negotiating
- Entrepreneurial knowledge, coaching, and mentorship
- Information about early small business funding

Focusing on women life scientists who are not yet entrepreneurs, the program objectives are for participants to gain self-efficacy and the belief that they could start a business and succeed, become more familiar with what is involved, and increase their intention to look into the possibility further. Assessment and enhancement of early entrepreneurial self-confidence, intent, interest, beliefs, and knowledge are emphasized. The overall program objectives are listed in Table 1.

Table 1. Program objectives

Women life scientists will gain more of the following with respect to starting a business:		
Self-confidence	•	That they could successfully start a business someday
	•	In describing their science and business ideas to others
Intentions to	•	Explore the career option of starting a life science business
	•	Take steps to develop their careers to improve their chances of business success someday
	•	Explore the option of obtaining SBIR funding
Beliefs:	•	That women scientists can succeed in business
	•	That starting a business is a viable career option for women scientists
Knowledge:	•	Understand common rewards and motivations associated with starting a business
	•	Have a realistic understanding of the potential life impact of starting a business
	•	Understand the different types of funding available for starting a small business
	•	Have a basic understanding of the overall process of obtaining an SBIR grant
	•	Recognize the key parts of a business plan
	•	Be able to describe career development steps and skills that would support entrepreneurship
	•	Learn basic components involved in successfully pitching a business idea

We created stories of twelve life scientist entrepreneurs at various stages of starting a business, mostly women, and five other life scientists who are looking into entrepreneurship or working at startups. By clicking on buttons, users navigate around the simulated lab and biotech center and interact with characters they meet by selecting questions to ask them. We used the conversations to deliver information about typical entrepreneur experiences including rewards and challenges, tips on how to succeed, and ideas for overcoming barriers to starting a business.

For example, to counter the barrier of women dropping out of science because of having few other women to work with, making them a minority (Engel et al., 2022), characters acted as role models for developing a network of women scientists outside the workplace and supporting each other by participating in formal and informal organizations.

To counter the problem of women entrepreneurs on average not asking for as much money as they need to fund their business and asking for less money than men (Swain, 2020), we created a mentor character who described the importance of asking for enough money and warning that reviewers will think you do not understand your project well enough if you ask for too little.

We acknowledged the concern about having enough time for family with the demands of starting a business and suggested one possible solution—if you are a founder, you can make flexible work arrangements. One character described starting a daycare in the same building as her business.

We countered the barrier of poor self-confidence in entrepreneur skills and not understanding aspects of starting a business by telling stories where scientists learned skills as needed. Characters also described working with mentors and partners having the skills needed.

We also targeted unique interests of women in business. For example, women's motivations for starting a business tend to differ from men's: Women are more likely to be motivated by a need for autonomy and freedom, and men are more motivated than women by a market opportunity (Kanze et al., 2018). Women are often motivated by making a difference in the lives of others, so we also had the characters describe the societal impact of startups, such as the benefits of creating practical applications of scientific discoveries and positive economic impact. Another interest we learned of in our focus groups is that many women enjoy working with other women and do not want to be a minority in the workplace. With fewer than 15% of the workforce in most startups being women (Engel et al., 2022) and women being hired less often for executive positions (Massachusetts Biotechnology Council, 2022), women are less likely to find work at a startup as an attractive option. The program highlighted that being able to choose your partners and coworkers as an advantage of starting your own business.

These are just some examples of many other conversational interactions we included in the simulations addressing motivations and barriers to entrepreneurship that can be addressed through information or personal action or change.

## *2.2 Program Evaluation*

We recruited early-career women life scientists using a convenience sampling of women in life science graduate programs and organizations for life science professionals through contact information available to the public. We focused primarily on graduate programs in a broad range of life sciences across the United States and members of professional organizations, both local and national.

The participants used their own computers to access the program online and completed a demographic survey with additional questions to describe their training, interests, and entrepreneurial experience as part of enrollment before starting the intervention. They used each of the two simulations for at least twenty minutes and reviewed supplemental materials for at least ten minutes. They completed online assessments immediately after completing the program. Using 5-point Likert-style agreement surveys, they rated their agreement with whether they experienced various categories of change that were objectives of the project. The surveys covered self-reported change in self-confidence, interest, belief, intention, and knowledge related to early entrepreneurship. They then rated the simulations, other content, and their overall satisfaction with the experience. They also completed a follow-up survey at least two weeks after the intervention, covering what they learned, changes experienced, and usefulness of the website. They were compensated with a \$45 gift card for the initial study and a \$15 gift card for the follow-up survey. We calculated mean agreement for each statement in these surveys.

## **3. Result**

### *3.1 Participants*

Participants were a diverse group of 28 women life scientists at an early stage in their careers (26 graduate students, post-docs, or interns; a fourth-year undergraduate student, and a worker in the industry) recruited from education programs across the United States. They represented a broad range of sciences including two or three each from biochemistry, genetics, molecular biology, cancer research, plant science, evolutionary biology, and food science.

Participants' interest in business before participating was low on average. A majority (85.7%) had no experience with business startups, none had taken steps to found a startup, and only a few had worked at startups. However, half of the participants had looked at information on starting a business within the past year at least a little.

### 3.2 Quantitative Results

Completing the study resulted in perceived change in self-efficacy, intention, interest, beliefs, and knowledge regarding life science entrepreneurship and related topics for a majority of participants (n=28 female life scientists) for nearly all areas measured in the evaluation using Likert-type agreement surveys (35/38 areas measured). A majority of participants agreed that they had changed with respect to goals of the program. Generally, participants reported increases in earlier stages of considering entrepreneurship, such as being interested in learning about it, more often than later stages of entrepreneurship, such as intending to start a business someday. The mean number and percent of participants who agreed (rating 4 out of 5) or strongly agreed (rating 5 out of 5) with survey statements are presented in Tables 2 to 5. Highlights from the Quantitative Results are in Table 2.

Table 2. Quantitative Results Summary

High rate of agreement (>70% of participants) that the following increased after completing the intervention:	
Confidence in . . .	<ul style="list-style-type: none"> <li>• Learning how to start a business (96.4%; 27/28)</li> <li>• Being able to make the right decision for me about starting a business (82.1%; 23/28)</li> <li>• Obtaining funds to start a business (75%; 21/28)</li> </ul>
Interest in . . .	<ul style="list-style-type: none"> <li>• Networking to advance my career (96.4%; 27/28)</li> <li>• Participating in organizations for women in the life sciences (85.7%; 24/28)</li> <li>• Learning better communications skills for being an entrepreneur (75%; 21/28)</li> <li>• Participating in organizations for women entrepreneurs (75%; 21/28)</li> </ul>
Belief that . . .	<ul style="list-style-type: none"> <li>• Women in the life sciences can successfully start businesses (82.1%; 23/28)</li> <li>• There is a lot of help available for women life scientists who choose to start a business (82.1%; 23/28)</li> <li>• Working with mentors is important for life scientists starting a business (82.1%; 23/28)</li> <li>• Women life scientists can help each other improve their chance of succeeding in business ventures (78.6%; 22/28)</li> <li>• Starting a life science business is a viable career option (75%; 21/28)</li> </ul>
Knowledge of . . .	<ul style="list-style-type: none"> <li>• Life science entrepreneurship in general (92.8%; 26/28)</li> <li>• The skills or professional help needed to successfully start a business (89.3%; 25/23)</li> <li>• The potential sources of funding for a new business (82.1%; 23/28)</li> <li>• The basic process of setting up a business (78.6%; 22/28)</li> <li>• The importance of protecting intellectual property (78.6%; 22/28)</li> </ul>

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	<ul style="list-style-type: none"> <li>• The topics included in a business plan (78.6%; 22/28)</li> <li>• The process involved in obtaining grant money from the government to start a business based on innovative research (78.6%; 22/28)</li> <li>• The impact starting a business often has on one's life (71.4%; 20/28)</li> </ul>
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Intention to . . .	<ul style="list-style-type: none"> <li>• Seek mentors to further my career (92.8%; 26/28)</li> <li>• Attend industry networking events (85.7%; 24/28)</li> <li>• Learn about opportunities for women-owned businesses (85.7%; 24/28)</li> <li>• Create a network of support with other women scientists (85.7%; 24/28)</li> </ul>
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Other statements. . .	<ul style="list-style-type: none"> <li>• If I wanted to start a business, I would be willing to work hard to help ensure its success (100%; 28/28)</li> <li>• This experience would be useful if I wanted to start a business (96.4%; 27/28)</li> </ul>
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Moderate rate of agreement (50% to 70% of participants) that the following increased after completing the intervention:

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Confidence in. . .	<ul style="list-style-type: none"> <li>• Succeeding if I tried to start a business (67.8%; 19/28)</li> <li>• Being able to start a business (60.7%; 17/28)</li> <li>• Being successful if I wanted to start a business (57.1%; 16/28)</li> </ul>
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Intention to. . .	<ul style="list-style-type: none"> <li>• Start a life science-related business, lab, or other service someday (53.6%; 15/28)</li> </ul>
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Interest in. . .	<ul style="list-style-type: none"> <li>• Starting a small business (64.3%; 18/28)</li> <li>• Learning the steps to starting a business (60.7%; 17/28)</li> </ul>
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Low rate of agreement (<50% of participants) that the following increased after completing the intervention

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Self-efficacy. . .	<ul style="list-style-type: none"> <li>• Managing a business (39.3%; 11/28)</li> <li>• I am already confident in these things (14.3%; 4/28)</li> </ul>
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Intention to. . .	<ul style="list-style-type: none"> <li>• Do what it takes to start a business (42.8%; 12/28)</li> </ul>
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Interest in. . .	<ul style="list-style-type: none"> <li>• Submitting an SBIR/STTR proposal someday. Only a minority agreed (32.1%; 9/28). A majority were neutral on the subject (64.3%; 18/28) or decreased (3.6%; 1/28). Two reasons were given most often for their interest being neutral: <ul style="list-style-type: none"> <li>◦ I already have a different career/life plan I feel strongly about (35.7%; 10/28)</li> <li>◦ I don't have an SBIR/STTR style business idea (32.1%; 9/28)</li> </ul> </li> </ul>
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### 3.3 Qualitative Results Summary

Around half of the participants volunteered at least one comment when they were given the opportunity at the end of the surveys. We analyzed their comments using simple content analysis. One participant said, “I really liked the wealth of information available both on the website and through the simulations. There was no shortage of readings, articles, case studies, and opportunities to hear answers to a variety of questions.” Many of the participants liked the simulated stories of women life scientists engaged in starting a business. Examples of user comments are in Table 3.

Table 3. Qualitative Results Examples

Positive comments volunteered by participants included:	<ul style="list-style-type: none"> <li>• “I appreciated how many stories of women life scientists were shared. It made the idea that I could start up a business feel more possible.”</li> <li>• “I enjoyed the conversations that the simulation presented, and different people, each with their unique stories/backgrounds/careers.”</li> <li>• “Exploring individuals at different stages of starting a business provided perspective on what you would need to achieve in each step in starting a business.”</li> <li>• “I like the case examples on the website, which help me to think about the chance for young scientists to start a business.”</li> </ul>
Criticisms of how the program was presented, included:	<ul style="list-style-type: none"> <li>• Several participants requested the addition of audio for the character’s dialogue.</li> <li>• Several participants did not like having to interact with characters in a simulation to obtain information and would prefer to read key point summaries. However, most participants said that they enjoyed the simulation approach and preferred it to just reading the information.</li> </ul>

### 3.4 Follow-Up Results

A majority of participants (78.6%; 22/28) completed the follow-up survey after 2 weeks. Results showed that a majority of the women continued to experience a strong impact on their knowledge and confidence with respect to skills and actions that would help them succeed in entrepreneurship. Even after two weeks, the experience improved several factors that would be supportive of scientists choosing to start a business for a majority of participants. Key results from the follow-up survey are in Table 4.

Table 4. Follow-up results

High rate of agreement (>70% of participants):	<ul style="list-style-type: none"> <li>• I feel confident about being able to find what I would need to start a business, with respect to . . .               <ul style="list-style-type: none"> <li>◦ Information (90.9%; 20/22)</li> <li>◦ Support (86.3%; 19/22)</li> <li>◦ Resources (90.9%; 20/22)</li> </ul> </li> </ul>
Moderate rate of agreement (50%	<ul style="list-style-type: none"> <li>• The experience changed how I think about</li> </ul>

to 70% of participants): entrepreneurship options for women in life sciences (68.2%; 15/22)

- I feel more confident I could succeed if I started a business (63.6%; 14/22)

Low rate of agreement (<50% of participants):

- I am more likely to start a business, on my own or with others, someday (18.2%; 4/22)
- I am more likely to consider working in a small business in the life sciences (27.3%; 6/22)

### 3.5 Program Evaluation Results

Participants ranked some aspects of the website BioStartupAdvice.com higher than others. They rated usability of the site, usefulness for women scientists interested in business, and non-simulation content highly. While nearly all participants found what they experienced interesting, only around half gave the simulations and stories high ratings (4 or 5 out of 5) for being captivating or engaging. Key evaluation results for the program are in Table 5.

Table 5. Key Program Evaluation Results

Overall Program	
<ul style="list-style-type: none"> <li>• High rate of agreement (&gt;70% of participants)</li> </ul>	<ul style="list-style-type: none"> <li>• This experience would be useful if I wanted to start a business (96.4%; 27/28)</li> <li>• What I experienced was interesting (92.8%; 26/28)</li> <li>• I would refer BioStartupAdvice.com to women life scientists who are interested in business (92.8%; 26/28)</li> <li>• Overall, this was a useful experience (89.3%; 25/28)</li> <li>• BioStartupAdvice.com succeeded in inspiring women scientists to consider starting a business (82.1%; 23/28)</li> </ul>
<ul style="list-style-type: none"> <li>• Low to moderate rate of agreement (0% to 70% of participants):</li> </ul>	<ul style="list-style-type: none"> <li>• (There were no moderate or low results for the overall program.)</li> </ul>
Simulation Ratings	
<ul style="list-style-type: none"> <li>• High rate of agreement (&gt;70% of participants):</li> </ul>	<ul style="list-style-type: none"> <li>• The simulations and stories were an effective way of conveying the subject matter (78.6%; 22/28)</li> <li>• It was easy to learn how to play and navigate the simulations and stories (92.8%; 26/28)</li> </ul>
<ul style="list-style-type: none"> <li>• Moderate rate of agreement (50% to 70% of participants)</li> </ul>	<ul style="list-style-type: none"> <li>• The simulations and stories were captivating from the beginning (57%; 16/28)</li> <li>• The simulations and stories were engaging overall?</li> </ul>

(57%; 16/28)

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- Low rate of agreement (0% to 50% of participants):
  - (There were no low ratings for the simulations.)
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#### Non-Simulation Content Rating

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- High rate of agreement (>70% of participants):
  - The Key Points and Tips in the simulation “Steps to a Startup” were interesting or useful (96.4%; 27/28)
  - The Challenges in “Steps to a Startup” supported my learning more about entrepreneurship (89.3%; 25/28)
  - The supplemental readings (e.g., “Read More”) were interesting or useful (87%; 20/23)
  - Self-Check surveys were helpful in understanding myself better regarding entrepreneurship (84%; 21/25)
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- Moderate rate of agreement (50% to 70% of participants)
  - What I experienced will affect my career positively (67.8%; 19/28)
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- Low rate of agreement (0% to 50% of participants)
  - (There were no low ratings for non-simulation content.)
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## 4. Discussion

The purpose of this study was to evaluate an online intervention that we developed to increase women life scientists’ interest in starting a business. We focused on early-career scientists, so that they can be aware of this career option, take steps to prepare for it, and watch for opportunities to develop a business at some point in their careers.

The program approach of two online simulations combined with traditional online reading and interactive learning was unique for the target audience of early-career women life scientists. The simulations were uniquely used to provide the scientists with the experience of meeting and interacting with simulated women scientist entrepreneur role models for mentoring and inspiration. The use of simulated characters to act as role models for how to achieve entrepreneurial success gives women scientists more opportunities to interact with women scientist role models engaged in business than they are likely to encounter in real life where relatively fewer such role models are available.

### 4.1 Discussion of Results

A majority of participants self-reported increases or changes in their self-efficacy, intention to take action, interest, beliefs, and knowledge about entrepreneurship in nearly all areas measured. Change was greatest for earlier stages of change in the direction of starting a business at some point in the future. For example, most of the women reported increased confidence in being able to learn how to start a business and increased knowledge of life science entrepreneurship after completing the intervention.

The simulation succeeded in increasing most of the scientists’ intention to engage in activities that would support them in becoming entrepreneurs someday in the future, even if it is not something that interests them currently. These activities are likely to support any life science career development, including networking to advance their career, seeking a mentor, and participating in organizations for women in the life sciences.

Nearly all participants agreed that the intervention would be useful if they wanted to start a business.

All participants agreed that they would be willing to work hard to ensure the success of a business if they wanted to start one.

The online simulation and other training about entrepreneurship resulted in increased interest in starting a science-related small business for a moderate majority of participants. Self-confidence about being able to start a business, being successful if they decided to start one, and interest in learning the steps involved also increased for a moderate majority of participants.

However, only a minority of participants reported increases in factors more directly associated with taking action to start a business, such as intending to start a business someday. Only around a quarter of participants agreed their intention had increased, and most participants (63.6%) neither agreed nor disagreed. Those who gave a neutral response or disagreed most often said the reason was that they already had other career plans, followed by preferring pure science that is not affected by the marketplace. Intention to start a business or even work in a small business was similarly low at follow-up two weeks later. The higher results for having an interest in starting a business than intending to start a business seem to indicate that participants' interest in startups had increased but they are not yet ready to commit to that plan of action. Women also may be deterred because of the low success rate of life science startups because the success rate is even lower for women-owned businesses due to receiving less venture capital.

Other reasons that may contribute to women in graduate school not being interested in starting a business include additional financial and time-related challenges to starting a business when graduating from a doctoral program. Most graduate students have significant student debt, and in the life sciences industry, they have opportunities to obtain fairly well-paying jobs. Other reasons that might deter women scientists from starting a business include family responsibilities or interest in starting a family and the time demands of working at a startup that might conflict.

The increased interest of a majority of participants in starting a business someday and increased intention to actually start a business by around a quarter of participants is significant, considering the low number (16%) of tech startups in North America founded by women (Stefanuto, 2023), that most participants were still in training, and that entrepreneurship is not for every life scientist.

While participants in our market surveys told us that the young adult age group would be the best age for our intervention, it may not be an age when starting a business is most likely to happen across the span of a woman scientist's career. The intervention is not wasted on this group, however. BioStartupAdvice.com provides a basic understanding of what is involved in entrepreneurship, encouragement for those who might enjoy starting a business someday, and skills and awareness of resources that will help set the scientists up for success if they ever do start a business.

Possible causes of some of the low results include:

- Only a minority of participants reported increased intent to “do what it takes to start a business.” This is a statement from an older validated entrepreneurial intent survey (Liñán & Chen, 2009) and may be an attitude not held by current young adults. Also, the statement may invoke thoughts of sexual harassment in the workplace. Further research would help clarify why participants rated this question so low. Participants gave a very high rate of agreement to a slightly modified statement, “If I wanted to start a business, I would be willing to work hard to help ensure its success,” suggesting that the low rate of agreement for the original statement is not related to not wanting to work hard.
- A majority of participants reported only a neutral change in interest in submitting a small business innovative research (SBIR) grant proposal someday. The reason for nearly all giving this rating was that they have a different career plan and do not have an SBIR-type research idea. Interestingly, none of them selected the choice of SBIRs being too difficult to obtain.
- Most participants did not agree that their self-efficacy in managing a business had improved, which was not surprising because this was not a focus of the program. We primarily focused on earlier phases of entrepreneurship.

- The modest impact of the intervention in general is not surprising, given how much there is to learn about starting a business and that participants were only required to spend 50 minutes on the intervention. Participants' reasons for low scores on change in self-efficacy confirmed that most of them were not already confident in entrepreneurship.

Our results confirmed the importance of diverse learning options because participants varied in the format they preferred. Some women liked the simulations as a way to learn about business and found simulations more interesting than just reading about the topic. However, most participants seemed to appreciate having the combination of simulations plus more traditional online content. The more traditional online content of key points, tips, quizzes, and online readings was rated more favorably than the simulations. Many participants said that they liked having the opportunity within the simulations to read more on topics that interested them, which was provided via links to the online readings. Because of the varied learning preferences among the participants, we decided to keep the multiple forms of content on the website.

A majority of the women gave the program design favorable ratings overall, including that they found it easy to navigate and interesting. Most said they would refer a colleague interested in starting a business to the website. On average, only a little over half of the participants agreed that the simulations were captivating from the beginning and engaging overall. In further product development, we will explore with the target audience ways to make the simulations more captivating and engaging. For example, we would like to determine whether it is related to some comments made about not liking the characters' level of realism or interactions with lab equipment.

#### *4.2 Strengths and limitations of the study*

A strength of this study is that it provides understanding of the mindset of early-career women life scientists, especially graduate students, with respect to their self-confidence, interests, beliefs, intention, and knowledge about entrepreneurship. A limitation was that the target audience, graduate students, have little spare time, so we limited the length of the intervention. Because the time participants spent on the intervention was so short (50 minutes), we anticipated that they would not show significant pre-to post-intervention change. A longer intervention, for example, as part of a graduate program, might increase its impact to the extent that it could be measured in a pre to post design study.

Many interventions to boost women's representation in science startups are aimed at increasing the number of women entering training in STEM subjects and establishing supportive communities (Srinivas, 2021). Many other programs are aimed at helping women who have already embarked on starting a business succeed. However, few programs address the interim period, between undergraduate studies and launching a business. Our approach of targeting women in the life sciences later in their training and early in their careers is unique.

This program attempted to address common needs women life scientists have in starting a business by helping them build confidence, gain understanding, and find positive role models for becoming entrepreneurs. The focus was on things that individuals can change and this study showed modest improvements in many early measures of knowledge, interest, confidence, and intentions regarding entrepreneurship. While the resources offered in the intervention described in this study for early-career life scientists can help, women need continued support throughout their careers if the number of women starting life science businesses is to increase.

Women still face other obstacles in succeeding at business, such as a low rate of venture capital (Srinivas, 2021). Barriers to entrepreneurship, such as bias against women entrepreneurs, are systemic and beyond the reach of an intervention aimed at helping individuals by changing understanding, knowledge, and motivation. Similarly, systemic changes are needed to compensate for the conflict between the high-paced startup environment and family responsibilities.

### **5. Conclusion**

Our approach of using online simulations to increase entrepreneurship by women scientists, using experiential learning, mentoring, and experiencing role models is unique. Combining simulations with more traditional online learning approaches of key points, tips, quizzes, and online readings is another

unique aspect of this program that helps it reach women having a broader range of learning style preferences. The program was successful in that it increased interest in becoming an entrepreneur for over a quarter of participants. Also, for a majority of participants, it increased interest in taking several steps that would support becoming an entrepreneur later.

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