MALATEST

# Future Skills Centre

## Evaluation of CASTL's Project: Knowledge and Insights for Future Proofing Biopharmaceutical Manufacturing Training

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FSC is a forward-thinking centre for research and collaboration dedicated to preparing Canadians for employment success. We believe Canadians should feel confident about the skills they have to succeed in a changing workforce. As a pan-Canadian community, we are collaborating to rigorously identify, test, measure, and share innovative approaches to assessing and developing the skills Canadians need to thrive in the days and years ahead. The Future Skills Centre was founded by a consortium whose members are Toronto Metropolitan University, Blueprint ADE, and Signal49 Research.



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# Executive Summary

The Future Skills Centre (FSC) provided funding to CASTL's *Knowledge and Insights for Future-Proofing Biopharmaceutical Manufacturing Training* under the Pathways to Jobs and SME Adaptability thematic priorities. Through their project activities, CASTL aimed to inform continued development of their biomanufacturing training curriculum to support the industry's demand for technically trained biomanufacturing workers.

R. A. Malatest & Associates conducted an independent rapid evaluation of the project to assess the extent to which project objectives were met and, where possible, to assess the impact of project activities on the short-term outcomes associated with the project. This evaluation collected data through a survey of employers, and semi-structured interviews with staff, employers, trainees, and project partners. This document summarizes the evaluation's design, methods, results and implications.

**Key Findings**

Insights from CASTL's National Hiring Outlook Survey revealed that the Canadian biomanufacturing sector continues to grow with 64% of employers indicating they plan to hire new staff in the next three years. Approximately 58% of employers identified the need for skilled workers in manufacturing, production, laboratory and development technician roles. However, employers note many potential candidates lack hands-on experience in good manufacturing practice (GMP), laboratory and production techniques. As a result, many biomanufacturers must provide new hires with additional training.

Biomanufacturers state that both financial and non-financial barriers impede their ability to provide training with approximately half citing costs of training and travel related costs as significant barriers, while more than one-third cited lack of appropriate training and time away from production floor as significant barriers to investing in their workforce development. Despite these barriers most employers have budgets for training; however, training budgets vary greatly, ranging from $0 for employee onboarding up to $25,000 for advanced level training.

The evaluation found that while some academic training programs were helpful, many do not provide hands-on biomanufacturing experience. As such, many employers must provide additional training when onboarding new hires on top of training in proprietary biomanufacturing operating procedures. CASTL has worked with employers to develop customized training while accommodating for such proprietary processes through non-disclosure agreements. Employers who have worked with CASTL expressed satisfaction on their collaboration with CASTL to design custom training that met their specific needs. This suggests that CASTL is meeting employer training needs and supporting SME adaptability.

Findings also suggest that barriers are being lowered for individuals looking to enter the biomanufacturing field. For example, short-term hands-on upskilling programs, such as those offered by CASTL, support job readiness for those transitioning to the sector. However, better awareness of job opportunities and career paths in biomanufacturing could help attract talent from other sectors. In

addition, biomanufacturers have begun implementing DEI policies to support a more inclusive workplace.

Although survey findings suggest that few biomanufacturers were aware of CASTL, CASTL is working to increase awareness of their programs through the dissemination of their National Hiring Outlook survey findings to industry, policy makers and academia at a nation-wide industry conference. CASTL is also using similar knowledge mobilization activities to build industry trust and pursue partnerships to enhance their training programs and reduce employer barriers to accessing training. Partnerships with academia will help provide graduates with hands-on biomanufacturing experience giving them an edge in a competitive market. Funding partnerships will help make CASTL's training more accessible to individuals and employers. Working with employers to develop customized training to address their specific needs will allow CASTL's to address the sector demand for a skilled workforce.

**Recommendations**

- Continue to build partnerships with industry, funders and academia. CASTL has demonstrated its ability to successfully collaborate with employers, funders and postsecondary institutions. However continued effort is needed to build partnerships that support the development of innovative training solutions to meet the training needs of employers and of those building or looking to pursue careers in biomanufacturing.
- Continue with marketing campaigns and knowledge mobilization events to vet research findings and help increase awareness of CASTL training programs. Sharing insights on biomanufacturing skills and training needs will help to vet CASTL's research and increase awareness of the training programs CASTL has developed to address these needs. Promoting success stories and case studies of CASTL's collaboration with employers, industry partners and postsecondary institutions will help to build the CASTL brand and confidence in their training programs among employers, employees and those looking to enter the industry.
- Consider conducting ongoing research and engagement with biomanufacturers to stay abreast of skills and training needs. Through their employer survey and follow up interviews, CASTL gained valuable insights on future hiring outlooks and the skills and training needs of Canadian biomanufacturers. Ongoing research and engagement with biomanufacturers is needed to ensure that CASTL's training remains responsive to the needs of the industry. While CASTL's While CASTL's National Hiring Outlook survey captured perspectives from across the country, findings suggest that additional research and engagement is needed to better understand regional differences and issues impacting the various sub-sectors of biomanufacturing.

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# 1. Project Objectives, Activities and Anticipated Outcome

The Canadian Alliance for Skills and Training in Life Sciences Inc. (CASTL) project, *Knowledge and Insights for Future-Proofing Biopharmaceutical Manufacturing Training,* aimed to inform continued development of their biomanufacturing training curriculum to support the industry's demand for technically trained biomanufacturing workers. Specifically, the project aimed to:

- Conduct a National Hiring Outlook survey to gather comprehensive data on the demand for skilled biomanufacturing workers to enhance their training policy and program design.
- Circulate best practices to attract and engage diverse audiences in training initiatives to help respond to the skills gap through various knowledge mobilization activities, including:
    - Developing and posting a case study showcasing CASTL's customized training as a best practice for the industry,
    - Producing a report to highlight results of the National Hiring Outlook survey, and
    - Presenting these results at the 2024 BIONATION conference.

This report summarizes Malatest's evaluation of and learnings from CASTL's project activities from June through November of 2024.

## 1.1 Rationale

A 2021 BioTalent Canada study suggests that Canada's bioeconomy is growing and will require 65,000 more workers by 2029. However, it is predicted that there will not be enough workers to meet this demand, with employers being able to fill only 25% of biomanufacturing related positions in 2029.[1] As biomanufacturing companies continue to expand and increase their capacity, they will need to onboard new employees and upskill/cross-skill their workforce. However, data are lacking on biomanufacturers' hiring outlooks and investment in human resource planning, capacity and training.[2]

The 2021 study also suggests that individuals from similar sectors (e.g., manufacturing, other life sciences) and newcomers have transferrable skills and should be considered as potential talent pools for biomanufacturing. However, additional training is required to make them job ready.[3] In order to develop training programs that meet the industry demand for highly skilled talent, CASTL must better understand the specific skills and training needs of biomanufacturers.

Research also stresses the benefits of collaboration and partnerships with post-secondary, biomanufacturers, industry associations, and government to develop a skilled biomanufacturing

[1] (BioTalent Canada, 2021).
[2] (Innovative Medicines Canada, 2023)
[3] (BioTalent Canada, 2021)

workforce.[4] To support the sharing of best practices and the development of partnerships, CASTL is looking to increase its knowledge mobilization activities and showcase their role in supporting Canada's biomanufacturing ecosystem.

## 1.2 Logic Model

This project explored the skills gaps in Canada's bioeconomy to inform biopharmaceutical manufacturing training through a survey of national biomanufacturing companies, a case study to highlight CASTL's custom training, and delivering results of their National Hiring Outlook survey as part of a presentation to the BIONATION 2024 Conference.

Proposed Theory of Change:

**If** up to date information about Canadian biomanufacturing skills gaps and training needs can be gathered and shared among industry stakeholders,

**Then** the insights and knowledge from industry can influence life sciences skills and training policies to support the development of biomanufacturing skills and training programs,

**Resulting in** workers trained with the skills needed in biopharmaceutical manufacturing,

**Contributing to** meeting the demand for individuals with industry-specific workforce skills in biomanufacturing for the next 3-5 years.

A complete logic model, which describes the program's activities, outputs, and anticipated outcomes, can be found in Appendix B. Although the logic model specifies intended short-term, intermediate-term, and long-term outcomes, only short-term outcomes are evaluated in this report as intermediate and long-term outcomes will take more time to be realized. The anticipated short-term outcomes included:

- CASTL has the insights and knowledge from industry to build the next phase of biomanufacturing skills and training delivery.
- CASTL gathers evidence on the industry pace of adoption of AI and industry 5.0 technology.
- CASTL gives training participants a competitive edge and a path to industry jobs.
- CASTL has the insights and knowledge to influence the life sciences skills and training policy agenda.
- CASTL has maximized knowledge mobilization with delivery partners, policy makers, industry, and stakeholders.

These short-term outcomes are based on the assumptions that biomanufacturing companies would be willing to participate and national partners would be willing and have the capacity to collaborate with CASTL for this project. Given the limitations around the project's timelines and limited stakeholder availability, the project sought to encourage employer and stakeholder participation through an online

[4] (BioTalent Canada, 2021; Government of Canada, 2021; Innovative Medicines Canada, 2023)

survey and virtual interviews. They also vetted results of their National Hiring Outlook survey at a national industry conference of biomanufacturing stakeholders. Additional limitations that may have impacted project results are noted in Section 2.6 of this report.

# 2 Evaluation Context and Background

Malatest conducted an evaluation of CASTL project activities to assess the extent to which objectives were met and short-term outcomes were achieved. This included assessing the effectiveness of the approaches used by CASTL to survey industry employers and associations on hiring trends for the next three to five years; the extent CASTL's customized training solutions met employer needs through the development of a case study, and the extent knowledge mobilization activities increased awareness of CASTL training and disseminated insights from their National Hiring Outlook survey. Data were collected between August and November 2024 and incorporated both qualitative and quantitative methods.

## 2.1 Key Evaluation Questions

Six key evaluation questions were developed in collaboration with CASTL. These questions formed the basis for survey and interview questions, as well as the results summarized in this report. The figure below shows the key evaluation questions along with sub-questions used to develop the data collection instruments. Please refer to Appendix C for the evaluation matrix.

**Figure 2.1 Project Specific Evaluation Questions and Sub-questions**

| Evaluation Questions | Sub-questions |
|---|---|
| 1. What is the current Canadian demand for technically trained biomanufacturing workers? | • What is the workforce outlook for the next 3-5 years?<br>• What are the competency needs of roles in biomanufacturing?<br>• What are the skills and training needs?<br>• To what extent have employers developed workplace policies related to diversity and inclusion? |
| 2. What do employers need to adopt a culture of biomanufacturing training? | • What are the barriers to accessing training?<br>• In what ways do employers invest in training? |
| 3. To what extent has the biomanufacturing industry adopted AI and industry 5.0 technology? | • What are the emerging technology trends for biomanufacturing? |
| 4. To what extent are related skills training practices responsive to industry needs? | • To what extent does CASTL's programs meet industry needs?<br>• What additional training should CASTL be developing in response to industry needs? |
| 5. How can the biomanufacturing ecosystem support job readiness for those transitioning to the sector? | • To what extent does CASTL's programs support job readiness for those transitioning to the sector?<br>• What are the job pathways for new entrants? |

| | |
|---|---|
| 6. What opportunities exist for collaboration with national partners in biomanufacturing training? | • How can/do industry stakeholders work together to address the training and workforce needs of biomanufacturing employers? |

The key evaluation questions were also aligned to questions developed by Future Skills Centre which focus on the thematic priority areas for Pathways To Jobs and SME Adaptability. The figure below shows the alignment of evaluation questions with the two focus areas.

**Figure 1.2: FSC Thematic Questions and Alignment with Project Specific Evaluation Questions**

| **FSC's Thematic Priority Questions: Pathway to Jobs** | **Alignment with Project Specific Evaluation Questions** | | | | | |
|---|---|---|---|---|---|---|
| | **Q1) Demand for workers** | **Q2) Adopt culture of training** | **Q3) AI & Industry 5.0** | **Q4) Responsive training** | **Q5) Support job readiness** | **Q6) Partnerships** |
| 1. What are the characteristics of effective placements for those transitioning to a new sector of employment? | | | | X | X | |
| 2. What do workers and jobseekers need to know to better manage their careers into the 4th Industrial Revolution, the Green Economy, or other major transformation affecting employment in Canada? | X | | X | | X | |
| **FSC's Thematic Priority Questions: SME Adaptability** | **Q1) Demand for workers** | **Q2) Adopt culture of training** | **Q3) AI & Industry 5.0** | **Q4) Responsive training** | **Q5) Support job readiness** | **Q6) Partnerships** |
| 1. How can approaches that effectively address SME barriers to investing in training and adopting better HR management practices be scaled up to become sustainable or self-sustaining? | | X | X | X | X | |
| 2. How do Canadian SMEs make decisions regarding investing in skills and HR development, and what behaviours or systems are associated with high levels of SME investment in training, use of high-performance HR practices, etc.? | | X | X | X | | |
| 3. What employer-led intermediation models are the most effective in aggregating and coordinating | X | X | X | | | X |

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| employer demand for upskilling and reskilling support? | | | | | | |

## 2.2 Lines of Evidence

Data collection methods to answer the evaluation and learning questions for this project included a brief literature, data and document review, a National Hiring Outlook survey of biomanufacturing employers and stakeholders, follow up interviews with survey respondents, and interviews with case study participants, employers, CASTL staff and key partners. This information was also assessed for its contribution to FSC's thematic priorities of pathways to jobs and SME adaptability. The table below summarizes the data collected per line of evidence.

**Figure 2.3: Data Collected per Line of Evidence**

| Evidence | Respondents | Information Collected | Sources or Sampling |
|---|---|---|---|
| Literature, data and document review (administered by Malatest) | Not applicable | Malatest reviewed previous studies, evaluations and reports, and biomanufacturing/life sciences strategies[5] to find appropriate contextual information and data that could be used to provide baseline or comparative information to address the evaluation questions. | Information was sourced from documents and reports provided by CASTL and online search of related documentation from other jurisdictions conducted by Malatest. |
| National Hiring Outlook survey (administered by CASTL and BioTalent) | n= 50 | Questions examined employer hiring needs, in-demand positions and skills, barriers to accessing training, training budgets, training gaps, types of training delivery, awareness and use of CASTL programs, use of AI and industry 5.0 technology, and implementation of accessibility, equity, diversity, inclusion principles and practices. | The survey was shared with CASTL's network of industry partners and industry associations through the BioTalent Canada Partnership Program. Prospective participants received recruitment emails detailing the purpose of the survey. Those who expressed interest were invited to |

[5] Biomanufacturing/life sciences strategies outlined by the Government of Canada and several provincial governments (B.C., Ontario, Québec, Nova Scotia, and P.E.I) highlighted challenges in accessing highly skilled talent for the sector (Government of Canada, 2021; Ontario, 2024; British Columbia, 2024; Québec, 2022; BioNova, 2018; BioAlliance, 2021).

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| | | | complete the survey online using SurveyMonkey. |
| National Hiring Outlook survey follow-up interviews (administered by CASTL) | n= 15 | Interview questions further explored the topics raised in the survey, including hiring and training needs, barriers to accessing training, training approaches, use of AI and industry 5.0 technology, and industry collaboration. | Survey respondents were asked their willingness to participate in an interview. To ensure representativeness, participants were selected based on company size and location across Canada. |
| Case study interviews (administered by CASTL and Malatest) | n= 4:<br>2 management,<br>2 employees who had received CASTL training | Interview questions were designed to address evaluation questions and focused on the extent to which CASTL met employer training demands. (Questionnaires are available in Appendix D). | Participants received an email invitation to participate in virtual interviews. Participation in an interview was voluntary and individuals were not identified in the case study without their expressed written consent. |
| BIONATION workshop participant survey (administered by CASTL) [6] | n= 46 | Questions included sources of talent, recruitment challenges, training needs, and preferred methods of training. | Workshop participants were polled in real time during the workshop. Participation was voluntary and individuals were not identified. |
| Staff and stakeholder interviews (administered by Malatest) | 8:<br>3 CASTL staff,<br>2 CASTL partners,<br>3 employers from BIONATION conference | Questions examined perceptions of industry demand for biomanufacturing occupation and skills needs, barriers to accessing training, and extent CASTL's programs help meet industry training needs. CASTL staff were asked their perspectives on how they | Malatest received participant contact information from CASTL. Participants were sent an email invitation. The invitation explained the purpose of the interview, that the interview was voluntary, and anonymous. |

[6] Malatest had intended to gather feedback via an online survey from participants attending CASTL's conference workshop. Although the survey was promoted during the workshop, participants did not reply to the survey request. It was surmised that the lack of response was due to the workshop being the last scheduled event of the conference, occurring late in the workday, after which conference delegates left the venue. In place of this, Malatest received real-time polling data from the workshop participants (i.e., BIONATION workshop participant survey). Malatest also added questions to the employer and partner interview guides to supplement the feedback from those attending the BIONATION conference.

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| | | achieved project goals, the challenges they faced and how they mitigated these challenges. (Questionnaires are available in Appendix D). | |

It should be noted that while pre/post-training survey data from participants in CASTL training programs was considered for comparison against case study participants that received CASTL training, the data were not directly comparable due to the customized nature of training for case study participants (e.g., training on proprietary processes facilitated by an NDA) and to differences in question and response formats among the instruments used to collect feedback.

## 2.3 Equity, Diversity, Inclusion, and Reconciliation

Malatest evaluated the extent to which the project incorporated an equity, diversity, inclusion, and reconciliation (EDI&R) perspective through:

- Reviewing National Hiring Outlook survey data collected on the number of biomanufacturing companies with workplace policies on inclusion, diversity, equity, and reconciliation,
- Reviewing literature on biomanufacturing workplace policies on inclusion, diversity, equity, and reconciliation,
- Reviewing CASTL's policies on inclusion, diversity, equity, and reconciliation, and
- Assessing the extent to which CASTL's work helps to lower barriers for underrepresented individuals looking to enter the biomanufacturing field.

## 2.4 Research Ethics

To ensure the evaluation followed protocols and best practices on conducting ethical research including ethics reviews, the following elements were implemented:

- All data from the survey and interviews were aggregated and reported anonymously, unless express consent was given to use their names (i.e. for the case study).
- To establish informed consent all evaluation participants were explained the following:
  - How their data would be collected and securely stored on our servers,
  - How their privacy would be protected according to applicable legislation, and
  - Participation was voluntary, and they could skip any questions they felt uncomfortable answering.

## 2.5 Limitations

A few limitations were experienced during this evaluation. Malatest took what actions were available to mitigate these limitations and remains confident in the strength of the evaluation. However, the following limitations should be considered when interpreting the findings.

- **Timelines**: The evaluation faced limitations due to time constraints. Data were collected through multiple lines of evidence (surveys, interviews, data tracking) to increase response rates and efficiencies where possible. An incentive was offered to encourage participation in the National Hiring Outlook survey and follow up interviews.
- **Online survey engagement:** The evaluation faced limitations with engagement in the BIONATION workshop participant follow-up survey which received no response. It was surmised that the lack of response was due to the workshop being the last scheduled event of the conference, occurring late in the workday, after which conference delegates left the venue. To mitigate the lack of data from this line of evidence, the conference host shared with Malatest feedback collected from 46 participants during the workshop. Malatest also added questions to employer and partner interviews to gain perspectives from those attending the conference.
- **Selection bias**. Participation in data collection activities was voluntary. This may have resulted in a selection bias where those who hold particularly strong views about the topic (whether positive or negative) may have been more likely to participate in the evaluation than those who were neutral or had no opinion. For example, interested individuals that were already engaged and invested in CASTL likely hold positive views about their training programs and level of engagement with biomanufacturers. To mitigate potential bias, companies who were invited to participate in the National Hiring Outlook survey were asked to respond with an expression of interest. These companies were then vetted to ensure they were operating within the sub-sector of focus for the survey (i.e., biopharmaceutical manufacturing). Those who were operating within the sub-sector of interest were sent a link to the survey. Quotas were established for completions by geographic region and company size to ensure representativeness. Those who did not qualify were informed that future studies might be more applicable to their fields or sub-sector. In addition, the majority of survey questions were closed ended questions focused on recall and process, rather than opinions. For the case study and partner interviews, participants were also asked to provide feedback on areas for potential improvement.

# 3 Findings around Implementation

***Industry engagement led to key insights for the project.***

CASTL staff indicated that their efforts to engage industry members represented a key component of this project. For example, by partnering with BioTalent Canada to administer their National Hiring

Outlook survey they were able to access a large network of employers and industry associations. Having such access helped CASTL attain their targeted number of survey completions with Canada-wide representativeness. In addition, more than half of survey respondents agreed to participate in an interview which allowed CASTL to reach a range of perspectives from companies of varying sizes and location across the country.

The alignment of CASTL's project with the timing of an annual industry conference, BIONATION,[7] helped to support the dissemination of their National Hiring Outlook survey findings. CASTL participated in a panel discussion in which they presented results to corporate executives, investors and policy makers. Staff noted that the conference setting was a great opportunity to raise awareness of CASTL's work and encourage increased collaboration among the various attendees.

> *"It was a great fit because most of the people that we wanted to share this information with were in the room at the time and we were able to commandeer a section of the agenda to give our presentation." (CASTL staff member)*

# 4 Findings around Relevance

The evaluation found that CASTL's National Hiring Outlook survey provided insights on the hiring outlook for biomanufacturing over the next three to five years, biomanufacturing-specific in-demand skills needs and training gaps, and barriers that impede employer investment in training. CASTL will use these insights to inform the design and delivery of their current and future training programs. This, in turn, will help ensure CASTL's programs are meeting employers needs and contributing to a pool of skilled talent in the biomanufacturing sector. CASTL has also shared their research insights and training best practices with industry, academia and policy-makers to engage their audiences in training initiatives to help respond to the identified skills gaps. This engagement also helps to increase awareness of CASTL, further the development of partnerships and attract funding investment.

# 5 Summary of Impacts and Outcomes

CASTL was successful in meeting its project's short-term outcomes. The project met its target of 50 survey completions and exceeded the target of 15 by completing 17 follow-up interviews for their National Hiring Outlook survey, which provided valuable insights on current and future hiring outlooks and in-demand skills needed for the biomanufacturing sector. This insight will help CASTL to align their training programs to industry need, in turn, helping to ensure that trainees have access to in-demand skills and a path to industry jobs. CASTL's knowledge mobilization efforts included presenting at an industry-wide conference, and publishing National Hiring Outlook survey results along with a case study

[7] (BIOTECanada, 2024).

demonstrating how CASTL's customized training supports the biomanufacturing industry. Figure 3.1 provides a summary of the project's short-term outcomes.

**5**

| Intended Outcomes | Actual Outcomes | Assessment |
|---|---|---|
| 1. CASTL has the insights and knowledge from industry to build the next phase of biomanufacturing skills and training delivery. | Insights about current and future hiring outlooks and in-demand skills were garnered via the National Hiring Outlook survey with 50 employers responding to the survey and 17 follow up interviews were conducted to gain a deeper understanding of survey responses. | **Achieved** |
| 2. CASTL gathers evidence on the industry pace of adoption of AI and industry 5.0 technology.[8] | Approximately half of employers surveyed recognize a need for future training in AI-related areas. The pace of AI adoption has been slow due to high costs and the need to validate AI systems through regulator bodies that oversee the industry. | **Achieved** |
| 3. CASTL gives training participants a competitive edge and a path to industry jobs. | Testimonies from the case study affirmed the benefits (e.g., meeting specific operational needs, ability to discuss proprietary information in a closed setting, reduced employee onboarding time) of CASTL's customized training. BIOVECTRA employees rated their satisfaction with the training received from CASTL as very good to excellent. | **Achieved** |
| 4. CASTL has the insights and knowledge to influence the life sciences skills and training policy agenda. | Insights about employer hiring and skills demand were garnered via the National Hiring Outlook survey and the BIONATION conference through discussions with employers, educators and policy makers. | **Achieved** |
| 5. CASTL has maximized knowledge mobilization with delivery partners, policy makers, industry, and stakeholders. | CASTL completed all planned knowledge mobilization activities including publishing the results of their National Hiring Outlook survey and case study on their website and participating in a panel discussion at the BIONATION conference. | **Achieved** |

[8] Industry 5.0 has been noted as the next industrial revolution which involves "the integration of humans working alongside robots and IoT devices in the automated industrial environments of the future" (Berg, 2022).

# 6 Findings by Project Specific Evaluation Question

## 6.1 Gaining Employer Insight into Skill Gaps

Insights from CASTL's National Hiring Outlook Survey revealed the need for skilled workers to fill manufacturing, production and laboratory technician roles in biomanufacturing. However, many potential candidates lack hands-on experience in good manufacturing practice (GMP), laboratory and production techniques. The lack of skilled workers means that employers face competition from other companies in the industry as they vie to attract and hire skilled employees.

### *What is the current Canadian demand for technically trained biomanufacturing workers?*

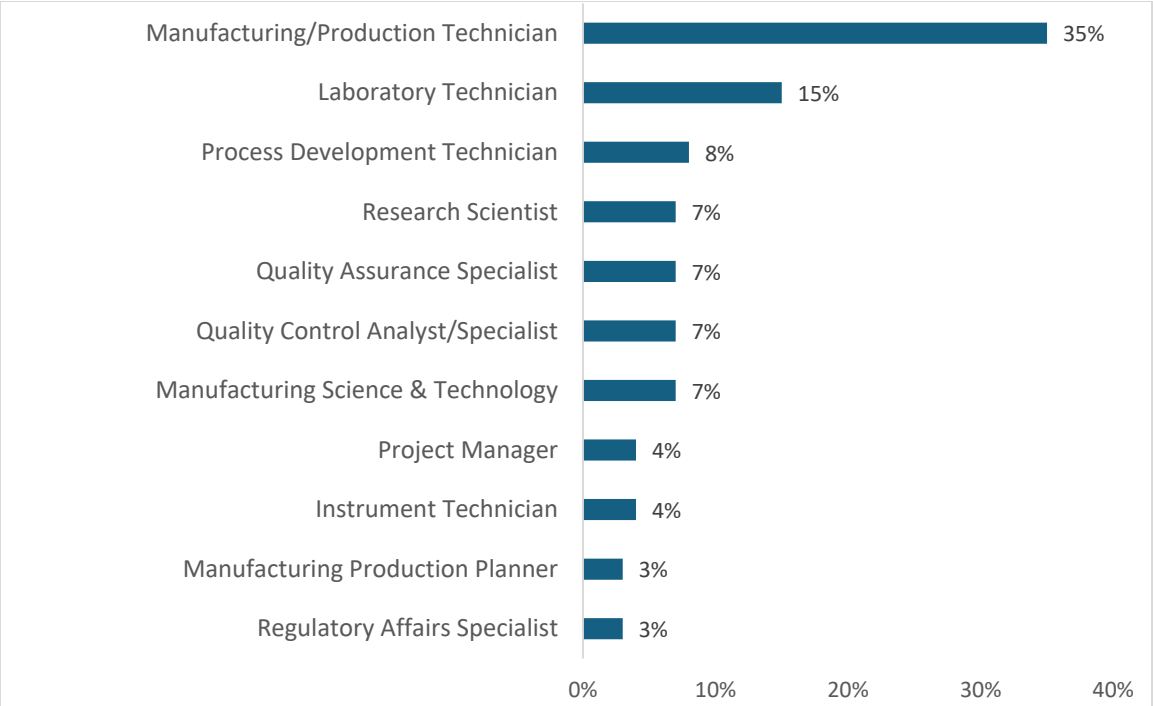
***The Canadian biomanufacturing sector is growing with the greatest demand for manufacturing and laboratory technician positions.***

Findings from CASTL's National Hiring Outlook survey revealed that the Canadian biomanufacturing sector continues to grow with 64% of employers indicating they plan to hire new staff in the next three years. In addition, smaller employers reported higher anticipated growth compared to larger employers.[9] Interviewed employers noted that hiring demand has been driven by several factors including government policy,[10] market demand, increased production capacity, and new biomanufacturing technologies. While employers note they are looking to fill a range of positions from entry level to managerial roles, the greatest demand is for manufacturing/production technicians and laboratory technicians, comprising half of projected new hires as shown in the figure below.

[9] (CASTL, 2024).

[10] The federal government created a Biomanufacturing and Life Sciences Strategy in 2021 to increase biomanufacturing capacity and develop a talent pipeline. Several provinces have also developed their own similar strategies which includes funding for the sector, including Ontario (2022), British Columbia (2023), Québec (2022), Nova Scotia (2018), and Prince Edward Island (2021) (Government of Canada, 2021; Ontario, 2024; British Columbia, 2024; Québec, 2022; BioNova, 2018; BioAlliance, 2021).

**Figure 6.1: New Positions and Replacement Hires by Occupation**




Source: CASTL Biomanufacturing Employer Survey (n=50)

***Employers look for candidates with hands-on experience in GMP, laboratory, manufacturing and production skills and techniques.***

As noted in the figure below, the top three skills most sought by biomanufacturing employers surveyed include good manufacturing practice (GMP), laboratory skills and techniques, and manufacturing and production techniques. In addition, the need for workers with hands-on technical experience was cited by 58% of employers.

**Figure 6.2: Technical Skills Employers Look for in Employees**


Source: CASTL Biomanufacturing Employer Survey (Multiple answers permitted; n=50)

This aligns with comments from employers who stated that while many candidates have academic qualifications, they lack practical experience including GMP, working in cleanrooms, and operating biomanufacturing equipment.

> *"In terms of finding skills, there's plenty of education, there is just not enough translation into the skills that would go into the industry. That's why even though I have seven people in my team, I'm the only one who's ever worked in a cleanroom or who's ever done any documentation or knows what good documentation looks like." (Biomanufacturing employer)*

***Employers face competition from other companies in the industry as they vie to attract and hire skilled employees.***

The competition for individuals with the required skills is strong with 52% of employers from the 2024 BIONATION conference indicating they hire individuals from other companies in the same industry.[11] This aligns with the National Hiring Outlook survey where the same proportion (52%) of survey respondents sourced new talent and replacement positions from other companies in their sector, with the trend being particularly prominent in provinces experiencing higher demand for skilled talent, including Ontario, Québec and British Columbia.[12] Interviewees noted that while hiring from other companies in the same industry is common across many industrial sectors, the lack of new workers with the hands-on experience employers are looking for exacerbates this among biomanufacturing employers.

## 6.2 Adopting a Culture of Biomanufacturing Training

Although most biomanufacturers provide training to their employees, the amount budgeted for training varies depending on the employee's position within the company. Barriers to investing in training are both financial, such as training and travel related costs, and non-financial such as, time away from production lines and lack of appropriate training. Interviewees suggested that increased collaboration among employers and training institutions, wage subsidy programs for training and work integrated learning opportunities, and simulation-based training will help employers adopt a stronger culture of biomanufacturing training.

### *What do employers need to adopt a culture of biomanufacturing training?*

***Employers do have budgets for training; however, training costs increase based on how advanced the position is within the company.***

The majority of employers surveyed indicated that they have budgeted for employee training with the reported average annual training budgets ranging from $1,000 for introductory-level employees to nearly $3,000 for advanced-level staff. However, the amount allocated varied widely among surveyed employers as shown in the figure below[13]

**6**

| Employee Level | Average | Minimum | Maximum | # Employer responses |
|---|---|---|---|---|
| Introductory level – new employee onboarding | $1,058 | $0 | $10,000 | 32 |

[11] BIONATION participant feedback survey (n=43); unpublished results.
[12] (CASTL, 2024).
[13] (CASTL, 2024).

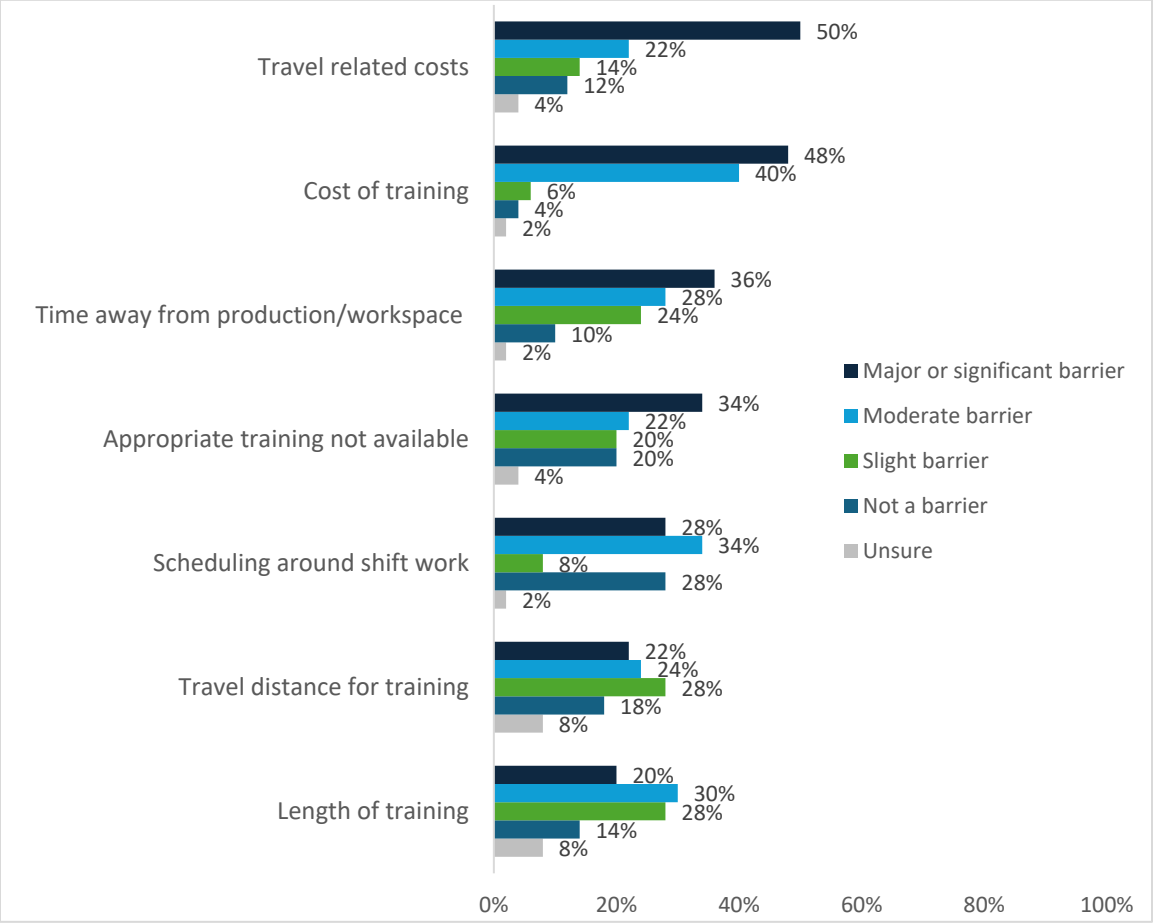
| | | | | |
|---|---|---|---|---|
| Introductory level – existing employee | $1,450 | $50 | $15,000 | 29 |
| Intermediate level | $2,243 | $200 | $25,000 | 30 |
| Advanced level | $2,918 | $200 | $25,000 | 28 |

Source: CASTL Biomanufacturing Employer Survey

***Biomanufacturers state that both financial and non-financial barriers impede access to training.***

As shown in the figure below, financial barriers including travel-related costs and the costs of training were cited as major or significant training barriers by 50% and 48% of biomanufacturers, respectively. More than a third of employers also noted time away from production, which can be considered as both a financial and non-financial barriers. Other non-financial barriers included inability to find appropriate training, or having to schedule training around shift work as major or significant (Figure 6.4).

**Figure 6.4: Employer Barriers to Training**




Source: CASTL Biomanufacturing Employer Survey (Multiple answers permitted; n=50)

***Sending employees for training or training them in-house are both equally costly.***

Interviewed employers explained that as most biomanufacturers are small to medium sized companies, their decision to send employees for training or train them in-house is primarily dictated by costs. With relatively few biomanufacturing training facilities in Canada, employers incur significant costs when they must send employees across the country for training. The option to train employees in-house is no less costly, especially for smaller companies who may not have the number of employees to justify bringing a trainer in-house.

***Increased collaboration, wage subsidy programs for training, and simulation-based training will help employers adopt a stronger culture of biomanufacturer training.***

Interviewees identified several tools and resources that could help address training barriers and encourage greater employer investment in training:

- Increased collaboration among employers, postsecondary institutions and training providers. Interviewees called for training providers such as CASTL and postsecondary institutions to increase collaboration among each other and with employers to develop programs that meet industry needs.
- Wage subsidy programs for employers to provide hands-on experience for student interns or to provide training to their employees. While acknowledging that wage subsidy programs do exist,[14] some interviewees suggested that such programs should be increased to allow for more biomanufacturers to provide employee training such as upskilling or reskilling, and paid internships, giving more students the opportunity to gain the practical experience biomanufacturing employers desire from potential candidates.
- Simulation-based training. Interviewees noted that virtual or simulation based training is being used in many life sciences programs; however few programs have specifically incorporated such training for biomanufacturing.[15] A few interviewees cautioned that the software for such virtual reality programs can be costly and investments in this type of training would need to be comparable to in-person training for employers to consider this type of training.

## 6.3 Adoption of AI and Industry 5.0 Technology

***To what extent has the biomanufacturing industry adopted AI and industry 5.0 technology?***

[14] Some wage subsidy programs are available for Canadian biomanufacturers looking to take on student interns; however, there is limited space and they often fill up quickly. For example, BioTalent Canada administers the Student Work Placement Program available to biotech employers; however, some biomanufacturers may not be aware of this program (BioTalent Canada, 2025).

[15] McMaster University offers a Master of Engineering in Biomanufacturing that includes virtual or simulation based training (McMaster University, 2025). BioTalent Canada is exploring the viability of developing a virtual reality twin cleanroom as a training tool for biomanufacturers and training providers; however, it is still in the development process.

***While many biomanufacturers recognized their benefits, adoption of AI and industry 5.0 technology has been slow.***

Interviewed employers cited several benefits of adopting AI and industry 5.0 technology in their business, including the ability to automate some biomanufacturing processes, and data analysis to improve production capacity or increase quality control. Others supported the use of digitization for their standard operating procedures and documentation logs. While approximately half of employers surveyed indicated they recognized a need for future training in AI-related areas,[16] uptake in these technologies have been slow.

Interviewees observed several reasons for the slow uptake in adapting AI technology. Some noted the costs involved given that they are small or startup companies with limited budgets. They stated that they were hesitant to acquire certain AI-related software because it was expensive and too big for their current needs. Others were concerned about data security, intellectual property protection and the complexity of validating AI-related systems with regulatory bodies like Health Canada as reasons for their hesitancy in adopting such technology.

## 6.4 Training Responsive to Industry Needs

Findings suggest that while training programs produce graduates with strong academic skills, they often do not provide their students with hands-on experience related to biomanufacturing. This means that manufacturers need to provide in-house training to give new hires practical basic GMP skills along with additional training on proprietary operating procedures and specialized equipment. Acknowledging this, CASTL has designed training responsive to the needs of employers, offering customized hands-on training to help reskill or upskill biomanufacturing employees. By establishing a non-disclosure agreement with the employer, CASTL is also able to offer training on proprietary processes to help address employer specific training needs.

***To what extent are related skills training practices responsive to industry needs?***

***Although some skills training programs were deemed helpful, many do not provide hands-on biomanufacturing experience.***

Interviewees and survey respondents observed that while Canadian postsecondary life sciences programs produce graduates who are strong academically, many lack practical experience, especially with biomanufacturing production processes. Interviewees indicated that most postsecondary programs offer limited hands-on experience outside of lab modules and more applied training in GMP and biomanufacturing is needed. They also noted that many graduates do not fully understand the

[16] (CASTL, 2024).

importance of good documentation practices, reporting requirements, and regulatory compliance which is essential for working in biomanufacturing.[17]

> *"Employers appreciate academic learning, but that hands-on value equation is increasingly noticed and stands people up in the piles of resumes and emails that people get. It makes a huge difference." (Biomanufacturing employer)*

***The majority of employers provide in-house training, due to lack of training providers offering hands-on experience and the need to train employees on proprietary processes.***

Interviewed biomanufacturers who provide in-house training to their employees indicated they do so due to a lack of training providers that offer hands-on experience and the need to train employees on manufacturing processes that are proprietary to the company. Interviewees noted that it often takes six months or longer to onboard new hires due to their lack of experience in applied GMP and reporting and documentation practices. This is then followed by training on proprietary processes and / or specialized biomanufacturing equipment.

Interviewees noted that the biomanufacturing sector is highly competitive with many new startups that have developed biomanufacturing processes or use specialized equipment specific to what the company produces. In addition, companies looking to expand their operations need to upskill or reskill their employees on new processes and state of the art equipment. The proprietary nature of their biomanufacturing makes it difficult to train employees off-site.

> *"Companies want to have an edge in terms of what services they provide in the marketplace versus their competitors, so they're constantly refining their biomanufacturing expertise and abilities." (Biomanufacturing employer)*

***Customized training and flexible training options help meet industry needs.***

CASTL has worked with biomanufacturers to develop customized training and flexible training options to meet industry needs. For example, CASTL worked with an employer to upskilled 25 of its employees to operate new production lines as their new mRNA biomanufacturing centre was being constructed. CASTL collaborated with company management to develop the program which included training on proprietary standard operating procedures (facilitated by an NDA) and hands-on practice using equipment and a configuration that mimicked the GMP-type biomanufacturing conditions of the employer's new facility. As the employees selected for upskilling were still working on active production lines, the customized program was delivered in small group sessions scheduled on days and times of convenience to accommodate for production cycles.[18]

> *"What I really enjoyed in working with CASTL so far is my contact has been more than willing to tailor the training. The other part was getting an NDA signed was*

[17] (CASTL, 2024).
[18] (CASTL, 2024).

> *really straightforward. I work with multiple companies where I know that legal can often be held up for ages, whereas this one was very streamlined." (Biomanufacturing employer)*

Interviewed employers also commented on CASTL's ability to successfully address their training needs. Reasons provided included keeping up with new and emerging technologies, training using state of the art equipment, trainers with experience in the field, and a willingness to work with employers to provide flexible training options (such as delivery mode, training dates and class sizes) and customize the training to meet specific needs. Interviewees noted that this versatility is essential in meeting industry needs.

> *"From a client service perspective, being able to be that versatile in your programming is going to be key going forward because as companies emerge into the space and increase their capacity, they're actually taking on different types of manufacturing. They may fall under the biomanufacturing umbrella, but there are subtleties to the technologies that are emerging through the manufacturing process that companies need to be able to address. CASTL is able to have that kind of flexibility and meet that sensitivity in terms of market niche for companies." (Biomanufacturing employer)*

## 6.5 Lowering Barriers for Individuals Looking to Enter the Biomanufacturing Field

The evaluation found that short-term hands-on upskilling programs, such as those offered by CASTL, support job readiness for those transitioning to the sector. Interviewees noted that better awareness of job opportunities and career paths in biomanufacturing could help attract talent from other sectors. In addition, biomanufacturers have begun implementing DEI policies to support a more inclusive workplace.

### *How can the biomanufacturing ecosystem support job readiness for those transitioning to the sector?*

***Although candidates transitioning from adjacent sectors have some transferable skills, they need additional training to be job-ready for biomanufacturing employers.***

Surveyed and interviewed employers observed that potential candidates coming from adjacent sectors such as pharmaceuticals, food production, and automotive manufacturing have skills that are transferable to biomanufacturing. However, even with such skills, these individuals still require additional training due to proprietary processes, regulatory requirements such as for GMP classified facilities, and specialized equipment used in biomanufacturing. Interviewees cited the need for short training courses,

especially those providing hands-on experience, as a means to quickly prepare individuals for biomanufacturing positions.[19]

***CASTL's programs support job readiness for those transitioning to the sector by providing hands-on training and short-term reskilling.***

CASTL staff noted that their training courses were designed to be short-term and focus on upskilling or reskilling individuals. While they provide hands-on training in their three facilities (located in P.E.I, Québec, and B.C.), staff indicated that they also offer online self-directed programs and virtual classroom instruction that helps increase access to training for those who cannot attend in-person training.[20] The majority of those receiving training in the first three quarters of 2024 expressed high levels of satisfaction with 96% in Q1, 92% in Q2 and 98% in Q3 giving CASTL programs a rating of four or five stars (out of 5 stars). This suggests that CASTL's programs are preparing trainees to be job ready.

***Employees receiving CASTL's customized training report high levels of satisfaction.***

In addition to supporting job readiness for those entering the sector or transitioning from other sectors, CASTL staff indicated that they also provide customized training to help employers upskill or reskill their workers. Trainees who received customized CASTL training featured in CASTL's case study were asked to rate their level of satisfaction with various aspects of the training. As shown in the figure below, the overwhelming majority of these employees rated their satisfaction with the instruction they received as very or extremely effective. This suggests that CASTL's training can support job readiness.

**6**

| Area of Training | Trainees Featured in Case Study (n=25) |
|---|---|
| Quality of instruction rated as very effective to extremely effective | 100% |
| Standard of equipment rated as very good to excellent | 100% |
| CASTL's training facility rated as very good to excellent | 100% |
| Overall Satisfaction rated as very good to excellent | 100% |

Source: CASTL Trainee Feedback Survey

CASTL trainees interviewed for the evaluation expressed satisfaction with the upskilling training they received. They noted that the material was presented in a digestible format using a combination of classroom theory and hands-on training. One interviewee highlighted how receptive CASTL trainers were. They commented that the trainer encouraged discussion and invited questions during training sessions. They also offered to review sections if trainees were struggling. Another interviewee appreciated the level of industry experience held by the CASTL trainers.

[19] (CASTL, 2024).
[20] Staff also mentioned they are working with industry partners to explore virtual reality training as an alternative to in-person hands-on training; however, this is currently only in the exploratory phase.

> *"I could definitely tell that they had industry experience, and they were very, very knowledgeable." (CASTL trainee)*

***Better awareness of job opportunities, career paths, and training in biomanufacturing can help those transitioning to the sector.***

Interviewees noted that biomanufacturing is a developing industry in Canada, as such, more needs to be done to promote job opportunities and career paths in biomanufacturing to help address the shortage of workers in this sector. A recent report points to the need for more outreach and initiatives to attract skilled talent from other sectors as well as newcomers and those from underserved populations to help build the talent pool.[21]

Short training programs such as CASTL's Elevate Program help to reskill newcomers and individuals coming from other sectors.[22] Interviewees commented that CASTL has begun to develop a name in the industry for providing credible training. However, findings from CASTL's National Hiring Outlook survey revealed low awareness of CASTL's training programs with close to half (48%) of respondents having no awareness of CASTL.[23] Interviewed staff agreed that they needed to continue to engage with industry, government and academia to raise awareness of their programs and promote their ability to meet employer training needs.

> *"CASTL, with the three operation sites, they've got a brand. They're able to reach out on a national footprint level to reinforce that there is a Canadian established, credible organization that can help fill their needs." (Industry association)*

***DEI policies can support a more inclusive workplace and reduce barriers to entering the biomanufacturing field, however more work is needed.***

The National Hiring Outlook survey found that many employers are supportive of having an inclusive workplace and have implemented or are in the process of developing DEI policies. Approximately one-third of surveyed employers reported having fully implemented diversity, equity, and inclusion (DEI) policies, while another third stated they were in the early stages of implementation. Employers who had made progress with DEI initiatives highlighted positive outcomes in promoting a more inclusive workforce.

However, many also shared challenges in translating corporate DEI policies into tangible, on-the-ground practices. Some companies noted that this process took time to implement and be adopted company wide. Several smaller companies and startups acknowledged the benefits of such policies, but indicated did not have the resources to fully develop and implement a suite of DEI policies.

[21] (BioTalent Canada, 2021).
[22] (CASTL, 2025).
[23] (CASTL, 2024).

## 6.6 Gaining Insights and Knowledge to Influence Life Sciences Skills and Training Policy

Through knowledge mobilization activities, CASTL has shared their insights with industry and policy makers. These activities have led to additional opportunities to present CASTL's National Hiring Outlook survey findings on an international level. In addition, CASTL's knowledge mobilization efforts led to the development of partnerships with industry, funders and academia that can help support job readiness for those looking to advance their career or are transitioning from other sectors.

### *What opportunities exist for collaboration with national partners in biomanufacturing training?*

***CASTL's National Hiring Outlook survey serves as a catalyst to encourage collaboration and partnerships to support biomanufacturing training.***

Interviewed CASTL staff noted that they were able to take advantage of a nation-wide gathering of employers, industry experts, academia and government representatives at the 2024 BIONATION conference to present insights from their survey of employers during a panel discussion entitled People Powering the Ecosystem.[24] By sharing this information, they hoped to add to the body of knowledge around biomanufacturing training needs and encourage greater collaboration among industry stakeholders. Attending CASTL staff affirmed that it was an excellent opportunity to engage in meaningful conversations while increasing awareness of CASTL and how they are supporting the development of a talent pool to meet labour demands.

> *"We want to be a leader in the space, a thought leader, and own the space. This study and the workshop gave us really a good platform to share information with clients, government, policy makers, and with academia; it elevated the knowledge offering." (CASTL staff)*

CASTL staff also noted that results of their research has sparked interest from international organizations and training programs. For example, the National Institute for Bioprocessing Research and Training (NIBRT)[25] invited CASTL to present their findings in December 2024 at a biomanufacturing conference in Dublin, Ireland. The US Center for the Biomedical Advanced Research and Development Authority (BARDA) has also expressed interest in learning more about their National Hiring Outlook survey results.[26]

***CASTL continues to pursue collaborations and partnerships to enhance training programs.***

CASTL staff indicated that the work accomplished during this project will help to guide the organization moving forward. For example, learnings from this project will help to guide the roll out of their new RNA

[24] (BIOTECanada, 2024).
[25] CASTL is a NIBRT global partner licensed to use NIBRT's training curriculum (NIBRT).
[26] BARDA is a global standard in biomanufacturing and pandemic preparedness (BARDA).

Factory School, a collaboration with support from the Government of Québec funded through CQDM and their AReNA project.[27] CASTL is also looking to do more work with academic institutions around work integrated learning programs that integrate CASTL training to provide hands-on biomanufacturing experience to postsecondary students in biotech and other life sciences programs.

Staff noted that results of this project also validated the need for employer support to access training programs. Interviewees commented on the importance of funding to support SMEs that are looking to train their employees. This need was identified through previous research[28] and prompted CASTL to secure federal funding to develop a new program that will subsidize 50% of employer training costs for upskilling and cross-training industry employees.[29]

> *"Between partnerships with industry and partnerships with some of these academic institutions, I think they're [CASTL] absolutely providing a lot of value." (Industry association)*

***CASTL's knowledge mobilization activities helped to raise awareness of the need for responsive biomanufacturing training programs; however, continued works is needed to build industry support and brand trust.***

CASTL's knowledge mobilization activities included circulating a press release for their research project,[30] presenting their National Hiring Outlook survey findings at a national conference and a regional bio-networking event,[31] and posting these survey findings and a case study on their website. Additionally, information about their project was posted on BioTalent Canada's website and BIONATION's conference summary webpage.

To promote CASTL's ability to meet industry training needs through customized programs, a case study was developed with project funding and published on CASTL's website. [32] Interviewed staff noted that the idea for a case study was inspired by their global partners who use this method to boost credibility in the biomanufacturing training space. Staff stated they wanted to share the case study as a best practice example for how custom training effectively supports biomanufacturers.

[27] (CQDM, 2024)
[28] (BioTalent Canada, 2021)
[29] (CASTL, 2024)
[30] The press release was circulated to close to 1,000 subscribers (industry partners and trainees) on CASTL's mailing list.
[31] The BIONATION conference September 26, 2024, and a bio-networking event hosted by the PEI BioAlliance in November, 2024.
[32] (CASTL, 2024).

> *"We had strong data from them that we could show as an example to other potential clients in the industry to highlight the importance of training at CASTL and how the ripple effect of training would impact the sector as a whole." (CASTL staff)*

CASTL staff indicated that they would continue to share insights from their National Hiring Outlook survey via conference presentations and one-on-one discussions with delivery partners, policy makers, industry, and other stakeholders to validate their findings.

# 7 Findings by FSC Thematic Question

***CASTL is developing the training programs to help build a pathway to jobs and SME adaptability in the biomanufacturing sector.***

CASTL's project, *Knowledge and Insights for Future Proofing Biopharmaceutical Manufacturing Training*, aligns with FSC's Pathways to Jobs theme by providing insights that will help guide the development of new training programs that will help workers and job seekers attain the skills needed to work in biomanufacturing. By engaging with biomanufacturing employers to better understand their training and workforce needs and collaborating to design custom training, CASTL is able to respond to employers' training needs, encourage investment in training and build highly skilled biomanufacturing talent. The figure below summarizes the alignment of CASTL's project with FSC thematic areas.

**Figure 7.1: Project Alignment with FSC Thematic Areas**

| Thematic Area and Questions | Project Alignment |
|---|---|
| **Pathways To Jobs**<br>1. What are the characteristics of effective placements for those transitioning to a new sector of employment?<br>2. What workers and jobseekers need to know to better manage their careers into the 4th Industrial Revolution, the Green Economy, or other major transformation affecting employment in Canada? | CASTL's training programs give candidates an edge by equipping them with the skills and experience employers demand.<br><br>CASTL's engagement with industry provides insight into biomanufacturing skills needs and hiring outlooks that guides the development of CASTL training programs, helping individuals looking to pursue a career in biomanufacturing make informed decisions. |
| **SME Adaptability**<br>1. How can approaches that effectively address SME barriers to investing in training and adopting better HR management practices be scaled up to become sustainable or self-sustaining? | CASTL has increased their training facilities from one to three since 2021 and also offers virtual and online training to help increase accessibility to training programs.<br><br>Partnerships with industry, funders and academia allows CASTL to deliver programs that |

| | |
|---|---|
| 2. How do Canadian SMEs make decisions regarding investing in skills and HR development, and what behaviours or systems are associated with high levels of SME investment in training, use of high-performance HR practices, etc.?<br>3. What employer-led intermediation models are the most effective in aggregating and coordinating employer demand for upskilling and reskilling support? | meet employer needs and encourage investment in training.<br>CASTL works collaboratively with employers to design customized training programs to upskill and reskill employees. |

## 7.1 Pathways to Jobs

### 7.1.1 Characteristics of Effective Placements

***What are the characteristics of effective placements for those transitioning to a new sector of employment?***

***CASTL's training programs equip candidates with the skills and experience employers demand.***

Trainees receiving CASTL's short-term, hands-on training programs reported high levels of satisfaction with the training they received. Biomanufacturers familiar with CASTL noted that the training offered successfully upskilled or reskilled individuals to work in biomanufacturing. Key partners noted that CASTL's three facilities located across Canada have helped to provide more local access to hands-on training in a GMP simulated biomanufacturing setting. In addition, CASTL is licensed to use training curriculum developed by an internationally recognized training institute. This ensures that individuals are trained to international standards for biomanufacturing.

### 7.1.2 Employment Transformation

***What workers and jobseekers need to know to better manage their careers into the 4th Industrial Revolution, the Green Economy, or other major transformation affecting employment in Canada?***

***Training best practices established through employer insight were used to inform CASTL training programs. More information on skills needs in the biomanufacturing industry and training responsive to these needs will help workers and job-seekers make informed decisions about their career in biomanufacturing.***

CASTL's engagement with employers has helped them establish training best practices and develop training programs are aligned to industry needs. This includes programs that train individuals on how to use leading edge equipment and technology, and providing hands-on experience in biomanufacturing

processes. Knowing what skills are required and which type of training best develops these skills will help workers and jobseekers make informed decisions to guide their careers.

## 7.2 SME Adaptability

### 7.2.1 Scaling Up and Supporting Sustainability

***How can approaches that effectively address SME barriers to investing in training and adopting better HR management practices be scaled up to become sustainable or self-sustaining?***

***CASTL continues to scale up their operations to increase SME's accessibility to training programs.***

Findings from the National Hiring Outlook survey suggest that some of the barriers to SME investment in biomanufacturing training is a limited number of training facilities and costs to send employers great distances to access the training. CASTL continues to increase access to its programs by successfully scaling up their training facilities from one P.E.I. facility in 2022, to a second Québec facility in 2023, and a third facility in September 2024 on the campus of British Columbia Institute of Technology,[33] providing employers and trainees with access to biomanufacturing training closer to where they are located. In addition to in-person hands-on training, CASTL also offers virtual classroom training and self-directed online learning, which in addition to making training accessible to those who cannot access in-person, the content can be tailored to meet specific training needs. This also means that employers can combine several training delivery modes to best fit their training budgets and reduce production downtime related to employee training.

### 7.2.2 Supporting Investment in Training

***How do Canadian SMEs make decisions regarding investing in skills and HR development, and what behaviours or systems are associated with high levels of SME investment in training, use of high-performance HR practices, etc.?***

***Partnerships with industry, funders and academia allows CASTL to deliver programs that meet employer needs and encourage investment in training.***

CASTL has successfully developed partnerships with employers, industry associations, funders and academia to support their delivery of programs that meet employer needs and encourage investment in training. CASTL works collaboratively with employers to provide targeted training that respects proprietary processes through non-disclosure agreements. In addition to the funding provided by FSC, CASTL has been successful in securing funding from a number of provincial and federal government departments.[34] Such funding has led to new training and subsidy programs (such as the BioWorks

[33] (CASTL, 2024; PEI BioAlliance, 2023; CASTL, 2022).
[34] CASTL's website provides a list of their partners: https://www.castlcanada.ca/en/our-partners.

Training Program that offers employers up to 50% off customized training)[35] to support employers to invest in training. CASTL continues to forge relationships with postsecondary institutions to ensure graduates have the skills and experience employers need.[36] This could encourage employers to consider offering more work-integrated learning experiences knowing that students have some hands-on experience in GMP.

### 7.2.3 Employer-led Training Models

***What employer-led intermediation models are the most effective in aggregating and coordinating employer demand for upskilling and reskilling support?***

***CASTL works collaboratively with employers to design customized training programs to upskill and reskill employees.***

Evaluation findings suggest that employer-trainer collaborations are most effective in providing upskilling and reskilling support to meet employer training needs. As demonstrated in the case study developed as part of this project, CASTL's customized training helped support a P.E.I. biomanufacturer's expansion into pDNA and mRNA vaccine manufacturing by reskilling its employees. CASTL worked with the employer to ensure the training was targeted and configured their training space to mimic the type and location of equipment to be used in the company's new facility. This allowed production to begin with fully trained staff once the employer's new facility was complete.

# 8 Recommendations, Implications, and Next Steps

CASTL has demonstrated that it is engaging with employers to support the development of training programs that will help to meet industry demand for qualified talent in biomanufacturing roles. A series of suggestions and recommendations emerged as ways to help CASTL address employer training needs. The evaluation concludes with implications for the funding of this and other similar projects.

## 8.1 Stakeholder Suggestions

Industry partners and employers interviewed were supportive of CASTL's efforts to gain insights on biomanufacturing skills and training needs and CASTL's design of training programs that help address these needs. They also offered a few suggestions for CASTL's consideration:

- **Continue to solicit feedback from biomanufacturing employers and other stakeholders to better understand workforce demand and skills needs.** Interviewees commended CASTL's

[35] (CASTL, 2024).
[36] CASTL currently has partnerships with the University of British Columbia, British Columbia Institute of Technology, University of Prince Edward Island, York University, BioCanRx, and Institut national de la recherche scientifique (CASTL , 2025).

research to better understand employer workforce skills and training needs in the biomanufacturing sector. They suggested that CASTL continue to take advantage of opportunities to present their research and vet these findings with industry experts and employers, federal and provincial government and academia. A few interviewees suggested that further research should be conducted to better understand biomanufacturing skills and training needs at the provincial level and among biomanufacturing sub-sectors.

- **Continue to raise awareness of CASTL training programs.** Interviewees noted that the biomanufacturing industry is highly competitive and that CASTL is not the only biomanufacturing training provider in Canada. In addition, survey findings indicate that while there is high satisfaction among employers who have accessed CASTL's programs and services, there was low awareness of CASTL among nearly half of survey respondents. Interviewees suggest that CASTL must continue to raise its profile and promote the benefits of their programs.
- **Continue developing training programs that address employer needs.** Interviewees acknowledged that CASTL training programs were addressing employer needs for skill biomanufacturing talent. A few interviewees suggested CASTL should look to developing additional training around documentation and record keeping, regulatory requirements and quality control systems as these are highly relevant skills that are often lacking in the workforce. Others suggested more training for T-cell manufacturing, plasmids, mammalian cells, transfections would also be beneficial.
- **Provide support for employers looking to access biomanufacturing training.** The National Hiring Outlook survey found that the cost of training was a significant barrier for nearly half of survey respondents. Interviewees suggested that providing some form of funding, subsidy or other incentive would encourage biomanufacturers to invest in training for their employees.

## 8.2 Recommendations

With the evaluation findings in mind, the following are recommended:

***Recommendation 1:*** **Continue to build partnerships with industry, funders and academia.** CASTL has demonstrated its ability to successfully collaborate with employers, funders and postsecondary institutions. However continued effort is needed to build partnerships that support the development of innovative training solutions to meet the training needs of employers and of those building or looking to pursue careers in biomanufacturing.

***Recommendation 2:*** **Continue with marketing campaigns and knowledge mobilization events to share research findings and help increase awareness of CASTL training programs.** Sharing insights on biomanufacturing skills and training needs will help to vet CASTL's research and increase awareness of the training programs CASTL has developed to address these needs. Promoting success stories and case studies of CASTL's collaboration with employers, industry partners and postsecondary institutions will

help to build the CASTL brand and confidence in their training programs among employers, employees and those looking to enter the industry.

***Recommendation 3:*** **Consider conducting ongoing research and engagement with biomanufacturers to stay abreast of skills and training needs.** Through their employer survey and follow up interviews, CASTL gained valuable insights on future hiring outlooks and the skills and training needs of Canadian biomanufacturers. Ongoing research and engagement with biomanufacturers is needed to ensure that CASTL's training remains responsive to the needs of the industry. While CASTL's National Hiring Outlook survey captured perspectives from across the country, findings suggest that additional research and engagement is needed to better understand regional differences and issues impacting the various sub-sectors of biomanufacturing.

## 8.3 Implications for FSC and Other Funding Organizations

**Funding that supports training responsive to industry needs can help meet demand for skilled talent.**

FSC supported CASTL's goals to address labour market needs in the biomanufacturing sector. This has allowed CASTL to invest in human resources and capacity building within their organization (for instance, by retaining staff with industry experience to deliver their training programs). CASTL has also successfully secured funding from other levels of federal government and provincial governments which has allowed them to scale up from one to three training facilities to serve regions across Canada. Additional support is needed to develop innovative training programs such as virtual reality training and work integrated learning on leading edge technology.

**Encouraging partnerships among employers, industry trainers, and postsecondary institutions will help address barriers to accessing training programs.**

CASTL has demonstrated its ability to collaborate with employers, international trainers and postsecondary institutions to design and develop training programs to meet demand for a skilled biomanufacturing workforce. However, more could be done to ensure graduates of training and academic programs have hands-on exposure to biomanufacturing environments and processes. Consideration should be given to supporting the development of partnerships among employers, industry trainers, and postsecondary institutions. This would help to address the barriers to investing in training and increase access to biomanufacturing training programs.

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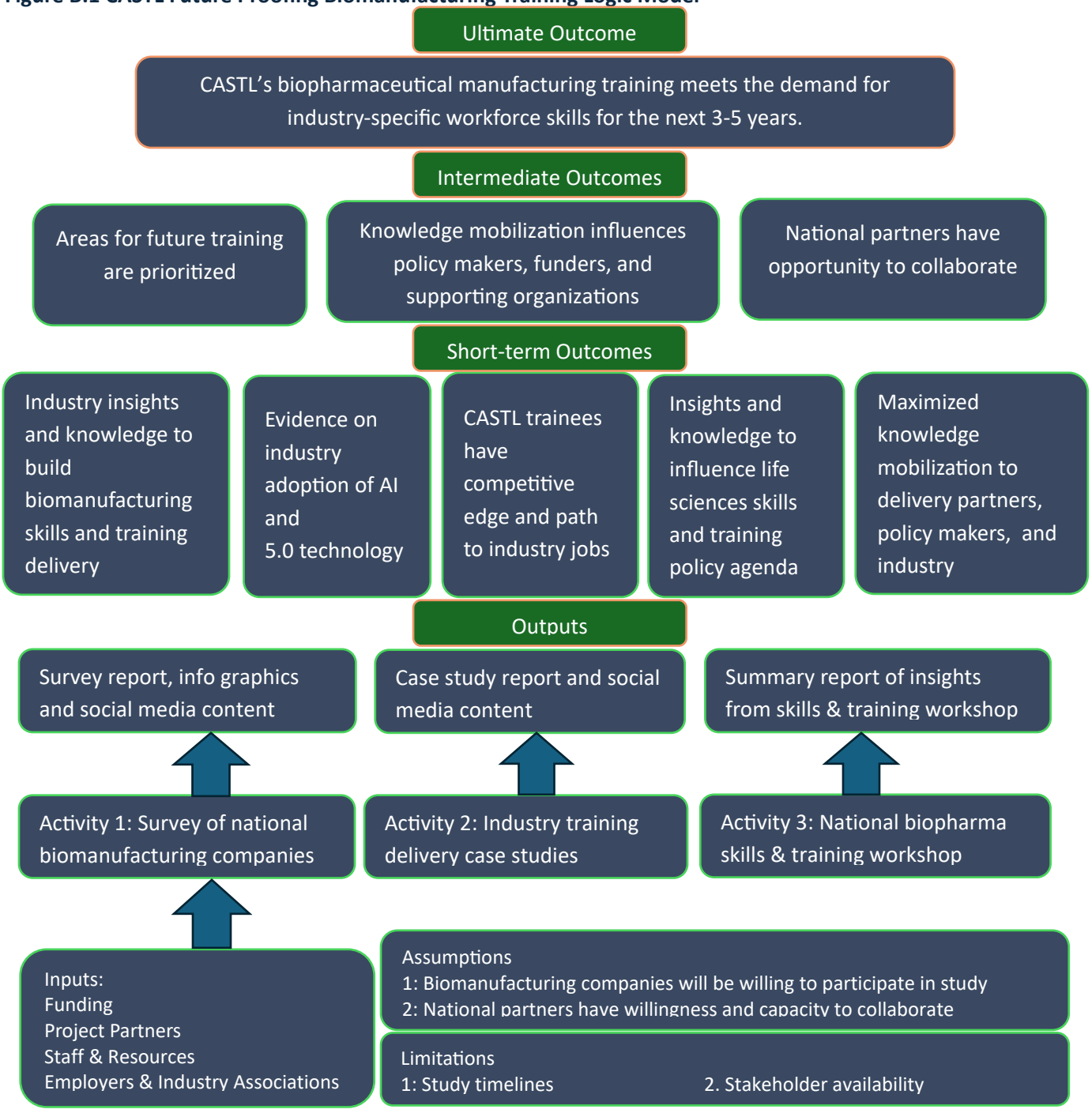
# Appendix B: Logic Model

**Figure B.1 CASTL Future Proofing Biomanufacturing Training Logic Model**



# Appendix C: Evaluation Matrix

The following evaluation matrix details the evaluation questions, sub-questions, data collection methods and sources.

**Figure C.1 CASTL Future Proofing Biomanufacturing Training Evaluation Matrix**

| Key Learning Questions Including FSC Strategic Questions | Sub-questions | Literature & Document Review | National Hiring Outlook Survey, Interviews | Case Study Interviews | BIONATION workshop feedback | Staff, Partner Interviews |
|---|---|---|---|---|---|---|
| 1) What is the current Canadian demand for technically trained biomanufacturing workers?<br><br>**Pathways to Jobs #2:**<br>**SME Adaptability #3:** | a. What is the workforce outlook for the next 3-5years?<br>b. What are the competency needs of roles in biomanufacturing?<br>c. What are the skills and training needs?<br>d. To what extent have employers developed workplace policies related to diversity and inclusion? | X | X | | X | X |
| 2) What do employers need to adopt a culture of biomanufacturing training?<br><br>**SME Adaptability #1:**<br>**SME Adaptability #2:**<br>**SME Adaptability #3** | a. What are the barriers to accessing training?<br>b. In what ways do employers invest in training? | X | X | | X | X |
| 3) To what extent has the biomanufacturing industry | a. What are the emerging technology trends for biomanufacturing? | X | X | | | X |

| | | | | | | |
|---|---|---|---|---|---|---|
| adopted AI and industry 5.0 technology?<br><br>**Pathways to Jobs #2**<br>**SME Adaptability #1, #2, #3** | | | | | | |
| 4) To what extent are related skills training practices responsive to industry needs?<br><br>**Pathways to Jobs #1**<br>**SME Adaptability #1, #2** | a. To what extent does CASTL's programs meet industry needs?<br>b. What additional training should CASTL be developing in response to industry needs? | X | X | X | | X |
| 5) How can the biomanufacturing ecosystem support job readiness for those transitioning to the sector?<br><br>**Pathways to Jobs #1, #2**<br>**SME Adaptability #1** | a. To what extent does CASTL's programs support job readiness for those transitioning to the sector?<br>b. What are the job pathways for new entrants? | X | X | X | X | X |
| 6) What opportunities exist for collaboration with national partners in biomanufacturing training?<br><br>**SME Adaptability #3** | a. How can/do industry stakeholders work together to address the training and workforce needs of biomanufacturing employers? | X | X | X | | X |

# Appendix D: Data Collection Instruments

This master interview guide has been developed for the following:

- CASTL staff
- Project partners

Each question has been labeled by stakeholder. This master guide will be split into individual guides prior to conducting interviews.

| **CASTL Interview Guide** | |
|---|---|
| The Canadian Alliance for Skills and Training in Life Sciences Inc (CASTL) project, *Knowledge and Insights for Future Proofing Biomanufacturing Training*, has been funded by The Future Skills Centre. The Future Skills Centre has contracted R.A. Malatest & Associates, an external and independent research firm, to conduct an evaluation of funded activities in collaboration with CASTL.<br><br>The purpose of this interview is to collect information for the evaluation including:<br>• Understanding the current demand for technically trained biomanufacturing workers.<br>• Responsiveness of skills training practices to meet industry needs.<br>• Extent of job readiness support for those transitioning to the sector.<br>• Extent biomanufacturing industry has adopted AI and industry 5.0 technology.<br><br>The interview will take approximately 30-45 minutes depending on your answers. | |
| **Confidentiality, Anonymity and Privacy:** | No one other than Malatest researchers will have access to any identifying information from this interview. Your responses to interview questions will be anonymized (that is, reported without your name or any identifying information attached). In some cases, we may use anonymized quotations that exemplify a trend among interviewees' responses; in this case, we will make sure that the quote does not contain any information that could be used to identify you. All identifying data will be destroyed by Malatest when the report provided to FSC is finalized.<br><br>Your responses will be protected *as per* Canada's *Privacy Act*. The information you provide will not be used for any purposes except those described above. Management of the information collected through this study will be compliant with Government of Canada's *Policy on Service and Digital*. For Malatest's privacy policy, please visit: https://www.malatest.com/Privacy.htm. |
| **Informed Consent:** | Your participation is voluntary, and you may end participation at any time. You can also skip any question that you do not want to answer, or that is not applicable to you.<br><br>With your permission, we will audio record this interview, for Malatest's notetaking and quality assurance purposes only. This recording will be destroyed once the interview notes have been verified and completed. Do I have your permission to audio record the interview? |

| | |
|---|---|
| **Questions:** | If you have any questions about this interview or this project, please feel free to contact April Balunda, Senior Research Analyst, R.A. Malatest & Associates Ltd., via email at a.balunda@malatest.com. |

**A. Background information**

*Ask all*

1. Can you tell me about yourself:
    a. What are your typical roles and responsibilities in your current job?
2. What are the specific occupational demands and skills needs for manufacturing employers?
    a. Are there particular competencies or skills that are required for those transitioning to biomanufacturing?
    b. Are there any barriers to accessing training faced by employers? Are employers generally willing to invest in training?
    c. Are there any barriers to accessing training faced by individuals looking to upskill or reskill in biomanufacturing?

**B. CASTL Training**

*CASTL staff, project partners*

3. To what extent has CASTL's training programs help biomanufacturing employers meet their needs for a skilled workforce?
    a. Has the training met employer demand? If yes, how were these needs met?
4. Is there an ongoing need for specific training or have needs changed? If so, what type of training is needed?
5. Are there any emerging technological trends for biomanufacturing that CASTL should be considering with respect to their training programs?
6. What, if any, were some of the challenges with the CASTL training?
    a. How were these challenges mitigated?
    b. Would you like to see anything done differently?

**C. CASTL Partnerships**

*Project partners*

7. How would you describe your partnership with CASTL?

a. What worked well?

b. What are the benefits of working with CASTL?

8. What, if any, were some of the challenges of working with CASTL?

    a. How were these challenges mitigated?

    b. Were there any areas that you felt could be improved or done differently?

9. Would you consider partnering with CASTL to support future training needs?

    a. Please explain why or why not?

    b. What are the benefits of working with CASTL on future training needs?

**D. CASTL Project Activities**

*CASTL staff*

10. From your perspective how effective were the knowledge mobilization activities, including the case study, in helping to attract and engage diverse audiences in the training initiatives that CASTL offers?

    a. What worked well?

    b. What, if any, were some of the challenges encountered by you or your team?

    c. How were these challenges mitigated?

    d. Were there any areas that you felt could be improved or done differently?

11. From your perspective how effective was the industry study in helping CASTL respond to skill gaps in the biomanufacturing industry and develop innovative solutions to address these labour market challenges?

    a. What worked well?

    b. What, if any, were some of the challenges encountered by you or your team?

    c. How were these challenges mitigated?

    d. Were there any areas that you felt could be improved or done differently?

**E. Wrap up**

*Ask all*

12. Do you have anything else to add, or any questions for me?

**Thank you for your time!**

| **CASTL Employer Interview Guide** | |
|---|---|
| The Canadian Alliance for Skills and Training in Life Sciences Inc (CASTL) project, *Knowledge and Insights for Future Proofing Biomanufacturing Training*, has been funded by The Future Skills Centre. The Future Skills Centre has contracted R.A. Malatest & Associates, an external and independent research firm, to conduct an evaluation of funded activities in collaboration with CASTL.<br><br>The purpose of this interview is to collect information for the evaluation including:<br>• Understanding the current demand for technically trained biomanufacturing workers.<br>• Responsiveness of skills training practices to meet industry needs.<br>• Extent of job readiness support for those transitioning to the sector.<br>• Extent biomanufacturing industry has adopted AI and industry 5.0 technology.<br><br>The interview will take approximately 30-45 minutes depending on your answers. | |
| **Confidentiality, Anonymity and Privacy:** | No one other than Malatest researchers will have access to any identifying information from this interview. Your responses to interview questions will be anonymized (that is, reported without your name or any identifying information attached). In some cases, we may use anonymized quotations that exemplify a trend among interviewees' responses; in this case, we will make sure that the quote does not contain any information that could be used to identify you. All identifying data will be destroyed by Malatest when the report provided to FSC is finalized.<br><br>Your responses will be protected *as per* Canada's *Privacy Act*. The information you provide will not be used for any purposes except those described above. Management of the information collected through this study will be compliant with Government of Canada's *Policy on Service and Digital*. For Malatest's privacy policy, please visit: https://www.malatest.com/Privacy.htm. |
| **Informed Consent:** | Your participation is voluntary, and you may end participation at any time. You can also skip any question that you do not want to answer, or that is not applicable to you.<br><br>With your permission, we will audio record this interview, for Malatest's notetaking and quality assurance purposes only. This recording will be destroyed once the interview notes have been verified and completed. Do I have your permission to audio record the interview? |
| **Questions:** | If you have any questions about this interview or this project, please feel free to contact April Balunda, Senior Research Analyst, R.A. Malatest & Associates Ltd., via email at a.balunda@malatest.com. |

## A. Background information

1. Can you tell me about yourself:
    a. What are your typical roles and responsibilities in your current job?

2. How did you learn about CASTL? Was it through the 2024 BIONATION Conference or had you heard or collaborated with them previously?

**B. <u>Industry Skill Demands and Needs</u>**

3. What are the specific occupational demands and skills needs for your company?
    a. Are there particular competencies or skills that are required for biomanufacturing?
    b. Do you face any challenges finding individuals with the skills you are looking for?
    c. Are you looking to upskill or reskill employees for your biomanufacturing?

**C. <u>Training</u>**

4. Is there an ongoing need for specific training?
    a. If so, what type of training is needed?
    b. Are there any emerging technological trends for biomanufacturing for which training is needed?
5. What, if any, barriers to accessing training does your company experience?
    a. Are you aware of any additional barriers to accessing training faced by individuals looking to enter biomanufacturing?
    b. To what extend does your company invest in training?

*If aware of CASTL training*

6. To what extent has CASTL's training programs helped biomanufacturing employers meet their needs for a skilled workforce?

*If accessed CASTL training*

    a. Has the training met your demand? If yes, how were these needs met?

7. What, if any, were some of the challenges with the CASTL training?
    a. How were these challenges mitigated?
    b. Would you like to see anything done differently?

**D. <u>CASTL Workshop presentation at the 2024 BIONATION Conference</u>**

8. Based on the material presented during the workshop, to what extent…..
    c. Did the group discussion address some of your company's training challenges?
    d. Did the group discussion address some of your company's talent acquisition challenges?
    e. Would CASTL training address your company's / industry training needs? [Ask *if not accessed CASTL training]*

9. Would you consider partnering with CASTL to support future training needs?
    c. Please explain why or why not?
    d. What are the benefits of working with CASTL on future training needs?

**E. <u>Wrap up</u>**

10. Do you have anything else to add, or any questions for me?

**Thank you for your time!**

| **CASTL Case Study *Employee Interview Guide*** | |
|---|---|
| Thank you for agreeing to participate in an interview about your engagement with the Canadian Alliance for Skills and Training in Life Sciences (CASTL). CASTL is looking to showcase its successes and talk about its challenges in meeting the training needs of employers.<br><br>The purpose of this interview is to gather information for a case study on CASTL's employer-sponsored training. The study, funded through the Future Skills Centre, aims to:<br><br>• Examine best practices for upskilling in new technologies for biomanufacturing.<br>• Demonstrate the return on investment for customized employer-sponsored training, including CASTL's methods for training a selected group of workers to transition into new process streams for facility expansion.<br><br>The interview will take approximately 60 minutes depending on your answers. | |
| **Privacy:** | By participating in this interview, you agree that the information you provide during the interview can be used for developing a case study of CASTL's training programs.<br><br>Your responses will be protected as per Canada's *Privacy Act*. The information you provide will not be used for any purposes except those described above. Management of the information collected through this study will be compliant with Government of Canada's *Policy on Service and Digital*. For Malatest's privacy policy, please visit: www.malatest.com/privacy-policy/. |
| **Informed Consent:** | Your participation is voluntary, and you may end participation at any time. You can also skip any question that you do not want to answer, or that is not applicable to you.<br><br>With your permission, we will audio record this interview, for notetaking and quality assurance purposes only. This recording will be destroyed once the interview notes have been verified and completed. Do I have your permission to audio record the interview? |
| **Questions:** | Funding for this work has been provided by The Future Skills Centre who have contracted R.A. Malatest & Associates, an external and independent research firm, to examine the impact of CASTL on the sector.<br><br>If you have any questions about this interview or this project, please feel free to contact April Balunda, Senior Research Analyst, R.A. Malatest & Associates, via email at a.balunda@malatest.com or Sidney Reid, Director of Client Services, CASTL, via email at Sidney@castlcanada.ca. |

## A. Background information

1. Can you tell me about yourself:
    a. What are your typical roles and responsibilities?
    b. What was your role prior to taking CASTL training?

c. Has your role changed since you completed the CASTL training? If so, was this as a result of taking CASTL training?

**B. <u>CASTL Training</u>**

2. How did you learn about CASTL training?
    a. Was information about the CASTL training readily available?
3. What were the specific occupational demands and skills needs that led you to CASTL training?
4. What were the strengths of the CASTL training?
    a. How has the training sessions in upstream, downstream, and fill-finish processes helped you in your current position and operational processes?
5. What impact has CASTL training had on your confidence in performing tasks in an mRNA and pDNA facility?
    a. How has your confidence in your ability to perform tasks changed since completing the training compared to before you started the training?
6. What were some of the challenges with the CASTL training?
    a. How were these challenges mitigated?
    b. What additions to the training experience would have been helpful?
    c. Would you like to see anything done differently?

**C. <u>Wrap up</u>**

7. Do you have anything else to add, or any questions for me?

**Thank you for your time!**

| **CASTL Case Study *Employer Interview Guide*** |
|---|
| Thank you for agreeing to participate in an interview about your engagement with the Canadian Alliance for Skills and Training in Life Sciences (CASTL). CASTL is looking to showcase its successes and talk about its challenges in meeting the training needs of employers.<br><br>The purpose of this interview is to gather information for a case study on CASTL's employer-sponsored training. The study, funded through the Future Skills Centre, aims to:<br><br>• Examine best practices for upskilling in new technologies for biomanufacturing.<br>• Demonstrate the return on investment for customized employer-sponsored training, including CASTL's methods for training a selected group of workers to transition into new process streams for facility expansion.<br><br>The interview will take approximately 60 minutes depending on your answers. |

| | |
|---|---|
| **Privacy:** | By participating in this interview, you agree that the information you provide during the interview can be used for developing a case study of CASTL's training programs.<br><br>Your responses will be protected as per Canada's *Privacy Act*. The information you provide will not be used for any purposes except those described above. Management of the information collected through this study will be compliant with Government of Canada's *Policy on Service and Digital*. For Malatest's privacy policy, please visit: www.malatest.com/privacy-policy/. |
| **Informed Consent:** | Your participation is voluntary, and you may end participation at any time. You can also skip any question that you do not want to answer, or that is not applicable to you.<br><br>With your permission, we will audio record this interview, for notetaking and quality assurance purposes only. This recording will be destroyed once the interview notes have been verified and completed. Do I have your permission to audio record the interview? |
| **Questions:** | Funding for this work has been provided by The Future Skills Centre who have contracted R.A. Malatest & Associates, an external and independent research firm, to examine the impact of CASTL on the sector.<br><br>If you have any questions about this interview or this project, please feel free to contact April Balunda, Senior Research Analyst, R.A. Malatest & Associates, via email at a.balunda@malatest.com or Sidney Reid, Director of Client Services, CASTL, via email at Sidney@castlcanada.ca. |

**A. Background information**

1. Can you tell me about yourself:
    a. What are your typical roles and responsibilities?

**B. CASTL Training**

2. How did you learn about CASTL training?
    a. Was information about the CASTL training readily available?
3. What are the underlying factors that led your organization to seek CASTL training?
    a. What were the specific occupational demands and skills needs for which you sought CASTL training?
    b. Is there an ongoing need for this specific training or have your needs changed?
4. How many individuals received CASTL training?
    a. What was the criteria used to select these individuals?
    b. What distinguished these individuals from other employees?
    c. Are you planning to train other employees? If so, would they receive the same or different training?
5. How did CASTL meet your training needs?
    a. How did CASTL enhance your staff's capabilities during the transition to your new site for manufacturing mRNA and pDNA vaccines? What worked well?

b. To what extent were the participants in the CASTL program knowledgeable and prepared upon transitioning to the mRNA and pDNA work environment?

c. To what extent did the training employees received from CASTL accelerate your staff's transition to their new work environment?

d. How much training time is reduced by the ability of CASTL trainees to apply their skills effectively in the workplace? Approximately how much internal training time was reduced by having employees train at a CASTL Facility?

e. To what extent has the CASTL- enhanced training contributed to reducing or preventing human error-associated deviations or training-related deviations in:

I. Aseptic processes

II. Upstream processes

III. Downstream processes

IV. Fill-finish processes

f. How has the customized training impacted your return on investment (ROI)? Can you provide specific examples that demonstrate the effectiveness of these trainings?

g. Are there any areas of the training that could be improved or done differently?

6. New technology, future trends and pathways to jobs:
   a. What are the characteristics of effective training and placements for those transitioning to a new sector of employment or upskilling/cross-training to fill roles?

   b. How has CASTL's' approach to the adaptation of new technology platforms in biomanufacturing ensured a smooth transition and effective upskilling of your employees?

   c. What future trends or innovations do you foresee happening in the industry?

      - How will these trends impact your organization?

      - Do you plan to adopt these new trends/technologies?

7. To what extent would you consider hiring individuals who have received CASTL training?
   a. Would such individuals require additional training?

8. Would you consider CASTL for delivering future training needs? Please explain why or why not?

**C. <u>Wrap up</u>**

9. Do you have anything else to add, or any questions for me?

**Thank you for your time!**