Vector Institute Guidance for AI-Related Master's Programs

The following document and accompanying AI-Related Master's Program Submission form are intended to provide guidance to Ontario master's programs seeking Program Recognition from the Vector Institute. Included in this document are the following sections:

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Background & Context: The Essential Requirements

The AI master's initiative of the Vector Institute (Vector) was established to support Ontario's growing AI ecosystem. Increasing the number of artificial intelligence (AI)-related master's graduates will help create a high-flow pipeline for Ontario's AI companies to source talent. The Province of Ontario has committed to this initiative in partnership with Vector.

This document has been prepared to provide guidance that supports and enables universities who are interested in offering new and/or enhanced AI-related master's programs. The Essential Requirements outlined below integrates the results of consultations that took input and advice from over 150 individuals, including a working group established by Vector comprising representatives from universities, government ministries, Vector industry sponsors and health sector organizations. The consultations and working group identified **eight priority skills/competencies** for core technical AI-related master's graduates:

1. **Technical computing skills** with, where relevant to the AI-related program's field of study, a particular focus on:
   - Visualizing data and results using appropriate software tools and libraries
   - Exhibiting good software engineering practices (e.g., code optimization, version control, software testing)
   - Programming in more than one computer language, choosing the most suitable language for the task

2. **Computational thinking skills** with, where relevant to the AI-related program's field of study, a particular focus on:
   - Formulating problems in a way that enables the use of computers and other tools to help solve them
   - Logically organizing and analyzing data
   - Representing data through abstractions such as models and simulations

3. **Mathematics and statistics** related to AI

4. **Integration skills** (i.e., the ability to integrate technical computing skills, computational thinking and knowledge and skills related to the domain in which the AI-related work is performed)

5. **Practical application skills** related to AI

6. **Core methodological skills** related to AI

7. **Collaboration and communications skills**

8. Knowledge of **ethics and societal implications of AI**

The consultation participants and working group members agreed that the AI-master's initiative should also support complementary AI-related master's graduates, i.e., master's graduates who have complementary knowledge and skills (including business skills, implementation skills and sector knowledge), who can work effectively on interdisciplinary teams helping to design, evaluate, refine and implement practical AI-related solutions and technologies that meet business and end user needs in real world settings. As such, a set of requirements for **complementary programs** has been established.

General Considerations

AI-related fields include, but are not limited to: data science, machine learning and deep learning, computer vision, natural language understanding, intelligent robotics, knowledge representation and reasoning, intelligent agents, intelligent user interfaces, and intelligent medicine.

The working group has determined that a guidance document alone cannot ensure that the essential requirements for AI-related master's programs are fulfilled because (a) it is not possible to issue guidance that speaks to all the potential variations in program design and (b) one or more expert panels will need to be involved to ensure that varying approaches to the AI-related content of new master's programs are of sufficient substance to meet employer needs.

Accordingly, Vector has established the **AI Program Review Panel** to operationalize the guidance gathered through the broader consultations. The panel assesses programs proposed by universities with demonstrable strength related to AI to determine whether the programs will be recognized by Vector as meeting the essential requirements.

All master's programs that are recognized as being AI-related by Vector need to fulfill the essential requirements and articulate program level learning outcomes that are specific to the field of study. Fulfilling the requirements set out in this guidance document, including panel approval, will not necessarily result in an approved program. Standard approval and quality assurance processes for new or modified programs will continue to be in effect.

A subset of new and enhanced AI-related master's programs will far exceed the essential requirements presented in this document and will produce world-class graduates. Vector will work with employers and AI experts to develop guidance and supports for world-class AI-related master's programs.

Vector will have a role in disseminating examples of programs and program elements that meet the essential requirements and programs that are deemed to be world-class, so that these programs can serve as models for institutions looking to enhance their own programs and/or develop new AI-related content.

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Core Technical Requirements

Vector will recognize new and enhanced core technical AI-related master's programs that are science, technology, mathematics and engineering (STEM) programs. These core technical AI-related master's programs will often be in computer science, engineering, mathematics or statistics, but can also be in other fields such as physics or informatics. Core technical AI-related programs must fulfill the following essential requirements in order to be recognized by Vector:

1. The program includes at least three (3) curriculum components[1] with learning outcomes focused on AI-related methodologies and applications
    a. At least one (1) curriculum component with intended learning outcomes focused on the application of AI-related methodologies to ensure that graduates have knowledge and skills related to algorithms and representations regardless of their application area. The focus of the AI-related methodology component(s) will vary depending on the master's program but it is strongly recommended that a machine learning curriculum component be offered. Other options could include: neural networks, deep learning, graphical models, reasoning under uncertainty, pattern recognition, planning, logic, and other topics.
    b. At least one (1) curriculum component that involves studying an AI-related application area in-depth to ensure that graduates are able to apply AI-related methodologies and have knowledge of their limits in solving problems. The focus of the AI-related application component(s) will vary depending on the master's program, but could include: computer vision, computational linguistics (NLP), intelligent robotics, intelligent agents, intelligent medicine, and other topics.

2. The program has learning outcomes related to communication, teamwork and interdisciplinary practice related to AI. This requirement could be satisfied through different forms of learning including, but not limited to, an internship with academic supervision and an industrial supervisor, or a capstone or culminating project.

3. The program has learning outcomes related to the ethics and societal implications of AI. This requirement could be satisfied through different forms of learning including a dedicated curriculum component or a module within an AI-related methodology or AI-related application course, or a thread that is integrated through and across courses.

[1] A curriculum component will often be a course (in-person or online), but a program could prepare master's graduates through various combinations of: classroom learning, distance learning, culminating or capstone projects, summer school, faculty-supervised research projects, etc. A curriculum component could be a topic or competency that is developed as a thread through multiple courses as opposed to a stand-alone component.

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Complementary Requirements

Vector will recognize new and enhanced complementary AI-related master's programs that may be STEM, business, social sciences or humanities master's programs. These complementary AI-related master's programs will integrate AI-related content into master's programs with a focus of study that applies AI technologies (e.g., business, public health, environmental sciences). Complementary AI- related programs must fulfill the following essential requirements in order to be recognized by Vector:

1. The program includes at least three (3) AI-related curriculum components with program level learning outcomes that are focused on AI-related applications and/or methodologies related to the primary field of study. The learning outcomes will ensure that graduates have sufficient knowledge of the relevant AI-related applications and methodologies to be able to contribute to AI-related work, providing essential input to the development, evaluation, refinement and implementation of AI-related methods, tools, products and services in real world settings, particularly those in the primary field of study.

2. The program has learning outcomes related to communication, teamwork and interdisciplinary practice related to AI. This requirement could be satisfied through different forms of learning including, but not limited to, an internship with academic supervision and an industrial supervisor, or a capstone or culminating project.

3. The program has learning outcomes related to the ethics and societal implications of AI. This requirement could be satisfied through different forms of learning including a dedicated component or a module within an AI-related methodology or AI-related application component, or a thread that is integrated through and across courses.

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Preparing a Program Submission

Programs are invited to complete the Program Submission Template and submit it along with supporting documentation to aimasters@vectorinstitute.ai. To streamline the process for program recognition, the documentation universities are asked to provide are generally in existence and/or have been developed for quality assurance purposes (see template for details) and will include:

- A program description
- A description of the curricular components, along with relevant course syllabi, and associated learning outcomes that address each of the essential requirements including:
    - AI-related methodologies and applications (at least three (3) AI-related curriculum components);
    - communication, teamwork and practice related to AI; and
    - the ethics and societal implications of AI.
- Enrolment projections (intake, total and steady-state)
- List of core faculty members contributing to the program delivery (i.e. instructors, supervisors, etc.)

In **Section 1** of the template, programs seeking recognition will select one of the following tracks:
Track 1: Enhanced or expanded existing master's programs. These programs currently exist and offer substantial content in an AI-related field. Curricular components and/or a collaborative specialization[2] may be necessary additions to prepare graduates to meet the essential requirements of a core technical, or a complementary, AI-related program.

Track 2: New master's programs in core technical or complementary AI-related fields. These are newly created programs built on existing strength in AI-related areas to produce highly qualified graduates to build capacity in core technical, or complementary, AI-related fields. These programs are expected to be have higher tuition fees than thesis-based masters and may be full cost recovery.

Track 3: New joint or distributed program in core technical or complementary AI-related field. These are inter-institutional joint programs delivered by two or more universities to leverage their respective resources and expertise in AI-related areas.

Note that tracks 2 and 3 require approval to commence from the Ontario Universities Council on Quality Assurance (OUCQA) prior to seeking recognition from Vector; however, universities are encouraged to consult with Vector early in the development stage if they plan to be part of the AI capacity-building initiative. Track 1 programs that have been modified or enhanced should have their program director consult with the appropriate office at their university to determine what approvals may be required.

[2] Collaborative specializations are intra-university fields of study that bring together the expertise from two or more existing master's programs to provide required (core) curricular components in the area of specialization.

Terms of Reference: AI Program Review Panel

Program Review Panels will review AI-related programs proposed by universities and make recommendations to Vector regarding which programs should be recognized as providing students with the skills and competencies identified by industry as essential for the AI workforce. Panels will review both core technical AI-related master's programs and complementary AI-related master's programs.

Program Reviewers
Vector will establish a registry of AI-related university experts and employers who hire AI-related talent who have agreed to serve as reviewers.

University Reviewers will be drawn from:

- All Vector faculty, including Vector faculty affiliates with research expertise in AI-related fields including: data science, machine learning and deep learning, computer vision, natural language understanding, intelligent robotics, knowledge representation and reasoning, intelligent agents, intelligent user interfaces, intelligent medicine and other AI-related topics.

Employer Reviewers will be drawn from:

- Individual representatives identified by Vector industry sponsors; and/or
- Health sector organizations with existing staff who work in AI-related fields including: data science, machine learning and deep learning, computer vision, natural language understanding, intelligent robotics, knowledge representation and reasoning, intelligent agents, intelligent user interfaces, intelligent medicine and other AI-related topics.

Chair and Membership of Program Review Panels

- Chair: Vector, Director, Academic Partnerships or delegate
- Two (2) [non-conflicted] registered University Reviewers per submission [3]
- Two (2) registered Employer Reviewers per submission
- Vector staff responsible for recording advice from panelists and taking notes to provide feedback to submitters
- One observer representative from the Ontario Universities Council on Quality Assurance (OUCQA)

When organizing a Panel to review one or more submissions, Vector's Academic Partnerships Unit will invite registered University Reviewers and registered Employer Reviewers to participate in the review of each submission, ensuring that quorum is met with a minimum of two university and two employer representatives. All invited reviewers will have expertise that aligns with the program-related AI field associated with the submission they are reviewing. If one or more of the invited reviewers is unwilling or unable to participate or has a conflict of interest, then alternate reviewers will be contacted from the appropriate reviewer group (i.e., university reviewer or employer reviewer).

[3] University and employer reviewers may be involved in the assessment of more than one submitted program.

Authority of Panels

Panels have the authority to make recommendations to Vector as to whether master's programs proposed by universities: i) fulfill the essential requirements for AI-related master's programs; and ii) assess whether the AI-related curriculum components of Track 1, 2 and 3 master's programs are of sufficient substance to meet employer needs.

Panels will not duplicate the formal quality assurance or accreditation processes for master's programs and therefore the documentation required is limited what is needed to fulfill their mandate. Note that while Panel recommendation is required for program recognition by Vector, it is not a substitute for Ontario's quality assurance process.

Conduct of Meetings

The Panel meetings will be conducted following well-established practices for peer-review of grant applications which include:

- Up front declaration of real or perceived conflicts of interest before materials are distributed.
- Conflicted individuals exiting the meeting during the discussion of a submission where they have real or perceived conflict of interest.
- Treating all submitted materials, and the identities of reviewers, as confidential.
- Having the Chair focus discussion time on submissions where there was variation in reviewer scoring to probe the causes of the lack of agreement.
- Having notes taken to keep a record of points raised during the discussion and the panel's recommendation.

Process for Panel reviews

1. Vector to ensure that each submission includes the required documentation.
2. A minimum of two university and two employer panelists will be assigned to each submission by the panel Chair or delegate.
3. Confirm acceptance of reviewer role and absence of real or perceived conflict of interest.
4. Panelists provide their scoring of submissions as well as comments, suggestions and feedback about ways that the proposed program could be strengthened to the Chair to share with program contact for consideration.
5. The panel will meet in-person or via teleconference to discuss each submission and provide recommendations on submissions.
6. In the event that a recommendation cannot be made due to insufficient information, the Chair will request additional supporting documentation from the submitter.
7. Submitters will be notified whether their program will be recognized by Vector and provided with:
    a. Comments and feedback from the Review Panel including suggestions regarding how their program(s) may be strengthened.
    b. Information about publicly available/open source curriculum components which the submitters may opt to integrate into their program.