Board 57: WIP - A Web-based Face Recognition Application for Better In-Person Learning

Shirley Qin, University of Toronto

Shirley Qin is a fourth-year Computer Engineering student at the University of Toronto. Previously, she worked as a System Integrator in City of Toronto's Infrastructure and Coordination Unit. She is interested in software programming and user interface design. She is proficient with C, C++, and JavaScript and familiar with Intel FPGA Verilog and ARM Assembly(v7).

Jiawei Tian, University of Toronto

Jiawei Tian is an undergraduate electrical and computer engineering student at the University of Toronto. He is interested in software programming and electrical systems. He is proficient with C/C++, Java and SQL and familiar with JavaScript, Verilog and Assembly.

Yuqi Yang
Miss Qian Guo, University of Toronto

Qian Guo is a fourth year Electrical Engineering student at University of Toronto. Previously, she worked as a Quality Analyst in SS&C Technologies. She is interested in software programming. She is proficient with C, C++ and Python and familiar with PSQL, Intel FPGA Verilog and ARM Assembly.

Mr. Junhao Liao, University of Toronto

Junhao Liao holds a Computer Engineering Bachelor degree from University of Toronto. Previously, he worked as a Teaching Assistant at University of Toronto. He is interested in software programming and User Experience designs. He is proficient with C, C++ and Python and familiar with JavaScript, PSQL, Intel FPGA Verilog and ARM Assembly(ARMv7-A).

Personal Website: https://junhao.ca

Dr. Hamid S. Timorabadi, University of Toronto

Hamid Timorabadi received his B.Sc, M.A.Sc, and Ph.D. degrees in Electrical Engineering from the University of Toronto. He has worked as a project, design, and test engineer as well as a consultant to industry. His research interests include the applicati

©American Society for Engineering Education, 2023

WIP - A Face Recognition Application to Improve In-Person Learning

Abstract
A face recognition application that enables instructors to conveniently know each student's name in the classroom is proposed. Communicating with students during lectures boosts more confidence and builds stronger relationships among students and their instructor, thus, enhances learning. The proposed solution is a web-based application that captures faces from videos and/or pictures through a User Interface that passes the data to a face recognition AI mechanism. The face recognition application also implements user management systems for privacy protection. With the Real-time Face Recognition Application, the course instructors can quickly recognize their students and address them by their names. A survey was conducted among 40 students to assess the comfortability of personal privacy, as well as the improvement of the learning environment in terms of engagement and readiness to engage in asking and answering questions during lectures. Over 85% agreed that instructors calling their names promotes a more friendly and engaging environment leading to improve the leaning.

1.0 Introduction

Positive students' relationships are fundamental to success in education. The likelihood that students will participate in learning and do better academically increases when they feel supported and recognized by the instructor. Nonetheless, knowing and remembering the students in the class may take an excessive amount of time. Other practices such as knowing and recognizing students by giving out name tags or having a self-introductory period at the beginning of the lecture is feasible for smaller class sizes. This method becomes impractical as the class size increases. It creates an additional workload for the instructors and brings certain disruptions to the orderly implementation of normal teaching and administration. It may compromise the course content [1]. Furthermore, during the covid pandemic, educational institutions utilized web meeting technologies in place for in-person meetings, i.e., online teaching. During online teaching, when instructors want to interact with students, they can call out their names without knowing them priorly. We are proposing to use face recognition algorithms to bring the convenience of web meeting technologies to in-person education environments. This will help instructors to know their students' names and build a better learning environment with a sense of community. Hence, students may develop more confidence, inspiring them to ask questions to learn more efficiently and feel more connected to their peers and instructors to encourage collaborations. The face recognition application captures faces from videos and or pictures through a User Interface that operates on web browsers and passes the data to a face recognition AI mechanism. User management systems will also be implemented to protect user privacy.

With the Real-time Face Recognition Application, the team believes that instructors (users) can quickly recognize and obtain basic information about their students. The scope consists of two system components. The backend component that compares stored faces with input faces and returns the corresponding name to the frontend in the case of successful recognition. And the frontend component will manage user requests and pass the input images to the backend for processing. The current design contains a core service module that hosts the face recognition function and a user management module that will allow users to change their privacy settings and support authentication purposes.

Technical design is discussed in section 2. Section 3 provides evaluation results. Risk affiliated with the proposed design is described in Section 4. Section 5 discusses the Future work.

2.0 Technical Design and Implementation

One approach to aid educators to make better connections with students and recognize students rapidly is to employ Artificial Intelligence (AI) mechanism. This section summarizes this design and its implementation.

2.1 System Level Overview

From a system level, the application can be broken down as shown in Figure 1. Foremost, the service users will need to input their account credentials (passphrase inputs) via mouse and keyboard to gain authentication of using the application service. Mouse and/or camera inputs are also needed to upload/capture the user images. These inputs are transmitted to the web application and are further processed. In order to store and retrieve related data, the application communicates with the databases (application and user management). The outputs (such as account information, extracted face images, and results of the face recognition) are then sent back to the browser for the service users to review and issue corresponding instructions.

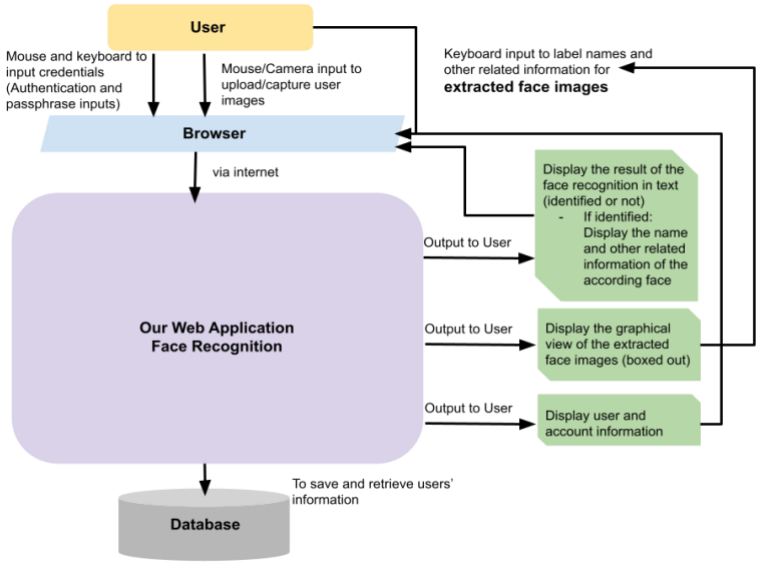


Figure 1: System level diagram.

2.2 Module Level Description

The module level diagram is shown in Figure 2. The application included in this module is comprised of two major parts: the core services module provides face recognition functions and the user management module provides account register/login/logout functions. The two modules can be broken down into the frontend and backend to handle the inputs, display, and connect to the application and user management database respectively.

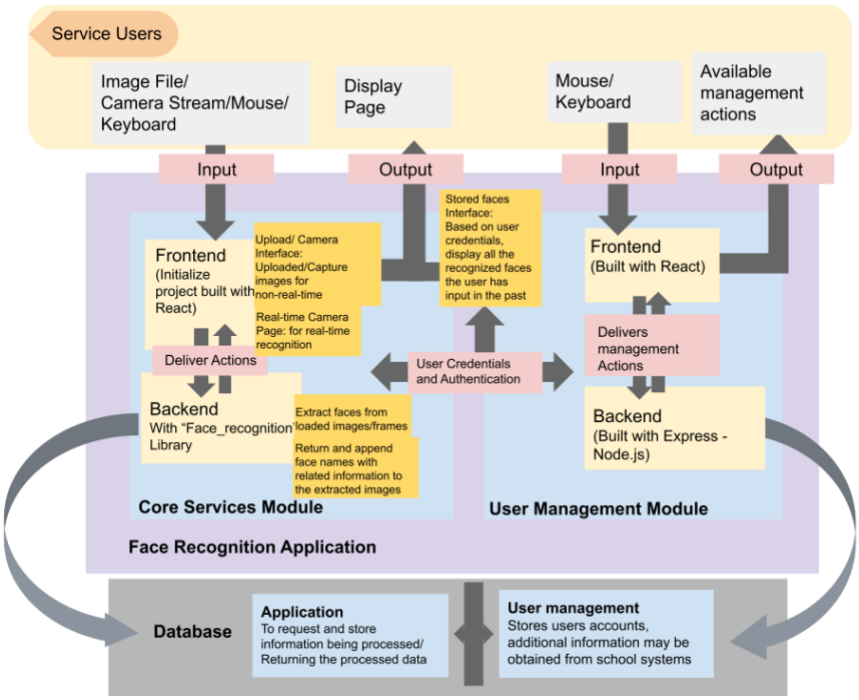


Figure 2: Module level diagram.

2.2.1 Core Services Module

The main services provided by the application are summarized in this section.

Inputs:

This is where the user interacts with the application as shown in Figure 3 and includes the followings.

- Uploaded image files from service users.
- Images captured from camera stream.
- Mouse and keyboard inputs from service users.

Outputs:

This is shown in Figure 3 and incorporates a graphical interface displaying:

- Extracted face images from loaded images.
- Identified face images with names and related information appended.

Figure 3: Illustration of recognition with image upload.

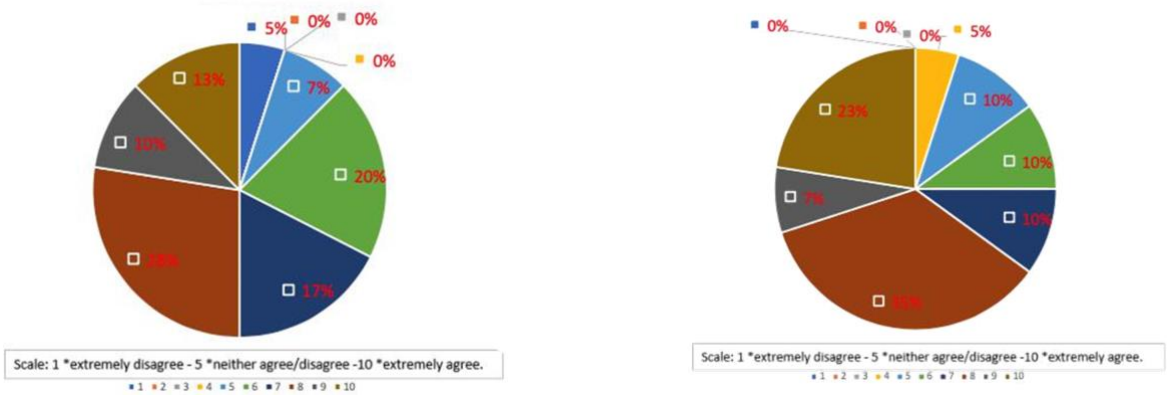
Functions:
The Core Services Module is implemented with the framework of *React.js* and an open-source *face_recognition* library. This module will allow users to upload image files containing faces to be identified, or access web cameras to stream and capture face images. For the uploaded and/or captured images, the backend of this module will first extract the facial landmarks of the faces [2]. If the face is identified, the name of the face with its related information from the application database will be returned to the frontend and displayed. For the faces not identified by the system, users can name those faces for future usage.

3.0 Evaluation

The prototype was verified through testing in order to determine whether it complies with the design specifications. A test plan was constructed and its details are provided in Appendix A. The prototype is tested for the functional requirement to determine if a person is identified accurately. Furthermore, the performance test demonstrated that the current prototype recognizes up to 137 faces in the uploaded image and responses within 1 second when recognizing less than 20 faces.

The acceptance survey results of using the application in terms of the students' comfortability about the potential personal privacy problems and improving learning environment in terms of engagement and willingness to engage in asking and answering questions during lectures were collected from 40 students. Appendix B provides details of the survey and its results.
In the survey, students where asked "*Are you comfortable with your name being called in class by instructor?*". Figure 4(a) shows the outcome of this question where 88% of the students agree and show their level of comfort.

Over 85% of students agreed that their level of confidence grew, and they became more inspired to participate in lecture activities when their professors address them by their names. Figure 4(b) shows the results of the survey where the following question was asked.
Do you consider the instructor knowing your name from a lecture improves your learning motivation and confidence in studying the course?



(a) ***(b)***

Figure 4: ***a)*** Survey results to the question: *Are you comfortable with your name being called in class by instructor?, and* ***b)*** 85% of the students agree that the results of using the application creates a more engaged and confidence-inspiring learning environment for students.

The survey result also shows that 76% of the students have no major problems with their faces being scanned during lectures. Nevertheless, 12% of the students expressed privacy concerns with using applications that gather facial biometrics information.

4.0 Risk Assessment

One of the risks is information security. In the design, both students' names and faces are kept in the server's database. In case of an information leak, students' biometrics and names will be compromised. A cloud platform, such as Amazon Web Services or Microsoft Azure, can be employed to host the database such to minimize the risk and any liability attributed to it. Alternatively, resources from the university, such as university's servers, can be utilized to ensure students' information security.

5.0 Future Work

The application proposed is a Work-In-Progress (WIP) and the application examined is for in-lecture teaching to recognize students and communicate with them by names. We are working on extending the applicability to other areas in education as discussed below.

It is noted that in some introductory courses the number of students is relatively large. And in many cases, more than 400 students write final exams [3]. The exam sign-in process which requires the signature of the student becomes tedious and is a time-consuming process for the exam organizers. Furthermore, verifying student's ID in comparing it with student's face can occasionally become a challenging task. The real-time face recognition application can assist in this situation and automate the process. Using the real-time face recognition application may also prevent impersonations during exams.

Some lectures, tutorials, and labs may require students' participations where partial marks are assigned. In these situations, the real-time face recognition becomes handy and can automate the process. Face attendance employs human biometric technology, which has several benefits over conventional attendance procedures. It is not only simple to manage and count, but also offers a guarantee of correctness as well as being real-time and operable.

6.0 References

[1] X. Zhang, X. Zhang, and J. B. Dolah, “Intelligent classroom teaching assessment system based on Deep Learning Model Face Recognition Technology,” *Scientific Programming*, vol. 2022, pp. 1–10, 2022.

[2] “ R. Verma, N. Bhardwaj, A. Bhavsar, and K. Krishan, “Towards facial recognition using likelihood ratio approach to facial landmark indices from images,” *Forensic Science International: Reports*, vol. 5, p. 100254, Oct. 2022.

[3] “University of Toronto Exam Centre,” *Montgomery Sisam*. [Online]. Available: https://www.montgomerysisam.com/project/university-of-toronto-exam-centre/#:~:text=Program%20spaces%20include%20two%20300,series%20of%20specialized%20testing%20facilities. [Accessed: 23-Feb-2023].

[4] “Facial point annotations,” *i·bug - resources - Facial point annotations*. [Online]. Available: https://ibug.doc.ic.ac.uk/resources/facial-point-annotations/. [Accessed: 01-Feb-2023].

[5] *Dlib C++ library*. [Online]. Available: http://dlib.net/face_landmark_detection.py.html. [Accessed: 20-Jan-2023].
***For Downloading the dataset:
http://dlib.net/files/data/ibug_300W_large_face_landmark_dataset.tar.gz***

[6] L. S. Branch, “Consolidated federal laws of Canada, Personal Information Protection and Electronic Documents act,” *Personal Information Protection and Electronic Documents Act*, 17-Feb-2023. [Online]. Available: https://laws-lois.justice.gc.ca/eng/acts/P-8.6/index.html. [Accessed: 10-Feb-2023].

[7] Maclean's, “Canada's best universities 2023: Average class size: Maclean's education,” *Canada's Best Universities 2023: Average Class Size | Maclean's Education*, 07-Oct-2022. [Online]. Available: https://www.macleans.ca/education/the-average-undergraduate-class-size-at-canadian-universi ties/. [Accessed: 20-Sep-2022].

8.0 Appendices

Appendix A: Specifications

This appendix provides details of the design specifications and corresponding test methods.

Table 1: The design specifications

#	Project Requirements	Verification Method
1	**Face Recognition Accuracy and Performance** **A.Real-Time Recognition** - Automatically capture the scene image from a camera device and perform facial recognition **B.Non-real Time Recognition** - Perform facial recognition with test image sets/user-uploaded scene images **C.Results Display** - Recognition results should be displayed on top of the captured/uploaded image **D.Recognition Accuracy**	**Test:** Automated runtime tests will be conducted with different sample sets/environment setups - **A. Real-Time recognition:** **Alternative1:** Sets of videos containing multiple faces appearing will be used **Alternative2:** Classroom environment setup with student volunteers (# of students >=20 [Appendix B] - **B. Non-real-time recognition:** **Alternative1:** Sets of images with a fixed number of faces will be used (# of faces within one image >=20)[Appendix B] **Alternative2:** User captured image (single-face images) - **C. Results Display:** Sets of images with at least 20 faces in one image will be used [Appendix E] - **D. Recognition Accuracy:** The Dlib dataset will be used to test the accuracy of this model [4,5]
2	**User-friendly** - Click counts to achieve a certain function in the application - User Friendliness Survey on intuitive operations, clarity, navigation, layout, colour design, display adjustment, and support features.	**Test:** The site will be automatically navigated through UI tests (performed on multiple browser-device-OS combinations) to ensure the outcome satisfies the requirements' objectives. Surveys will be also handed out to volunteer participants for UI feedbacks

Appendix B: Survey Results

The acceptance survey results in terms of the students' comfortability about the potential personal privacy problems and improving learning environment in terms of engagement and willingness to engage in asking and answering questions during lectures were collected from 40 students. The results are converted to pie charts with descriptions. Figure 5 shows a list of survey questions.

Survey on **comfortability** and **improving learning environment** with Applications Gathering facial biometrics informa.

Please answer the following questions(Scale: 1 *extremely disagree - 5 *neither agree/disagree -10 *extremely agree.):

1. Are you comfortable with your face being scanned in class?

_____

2. Are you comfortable with your name being called in class by the instructor? (when you want to answer a question 🙋)

_____

3. Are you comfortable with your face being scanned during exams? (instead signing your signature on a sheet of paper)

_____

4. Are you comfortable with your face image being collected into the application database?

_____

5. Are you comfortable with instructors recognizing you and remembering your name? (as the result of using the application)

_____

6. Do you consider the instructor knowing your name from a lecture improves your learning motivation and confidence of studying the course/creates a more engaged and confidence-inspiring learning environment for students?

Figure 5: The list of survey questions conducted among participating students.

Figures 6, 7, and 8 shows survey results where the questions asked is shown in the Figure.

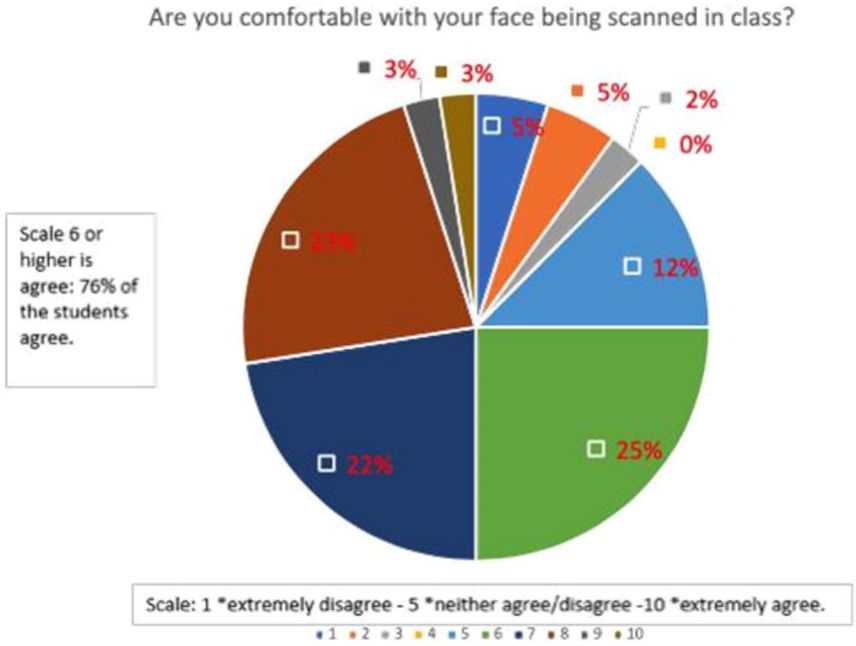


Figure 6: 76% of the students agree that their faces are scanned in class.

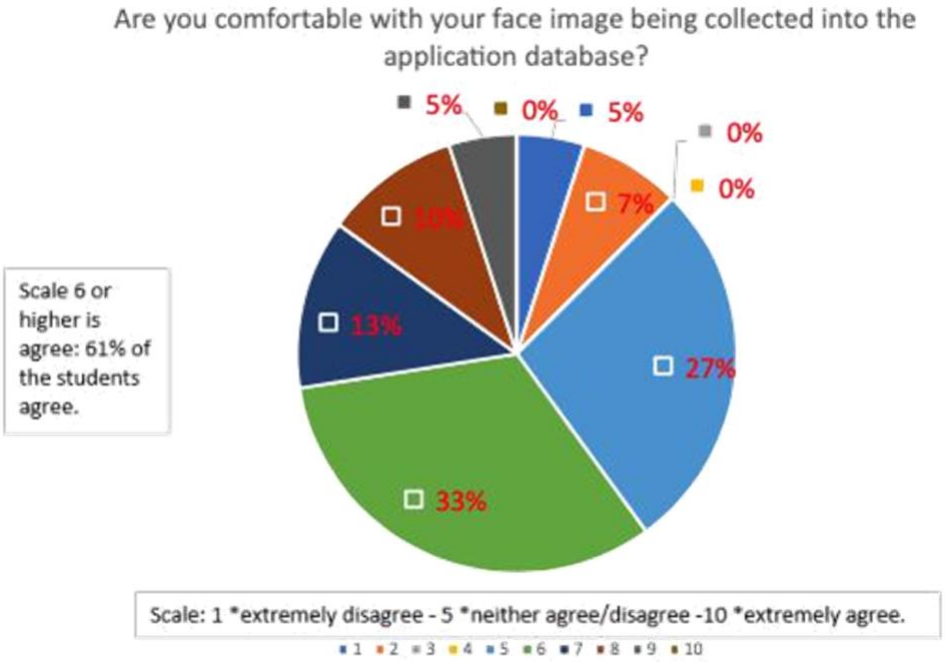


Figure 7: 61% of the students agree that their facial biometrics information is collected by the application, and 12% of the students disagree.

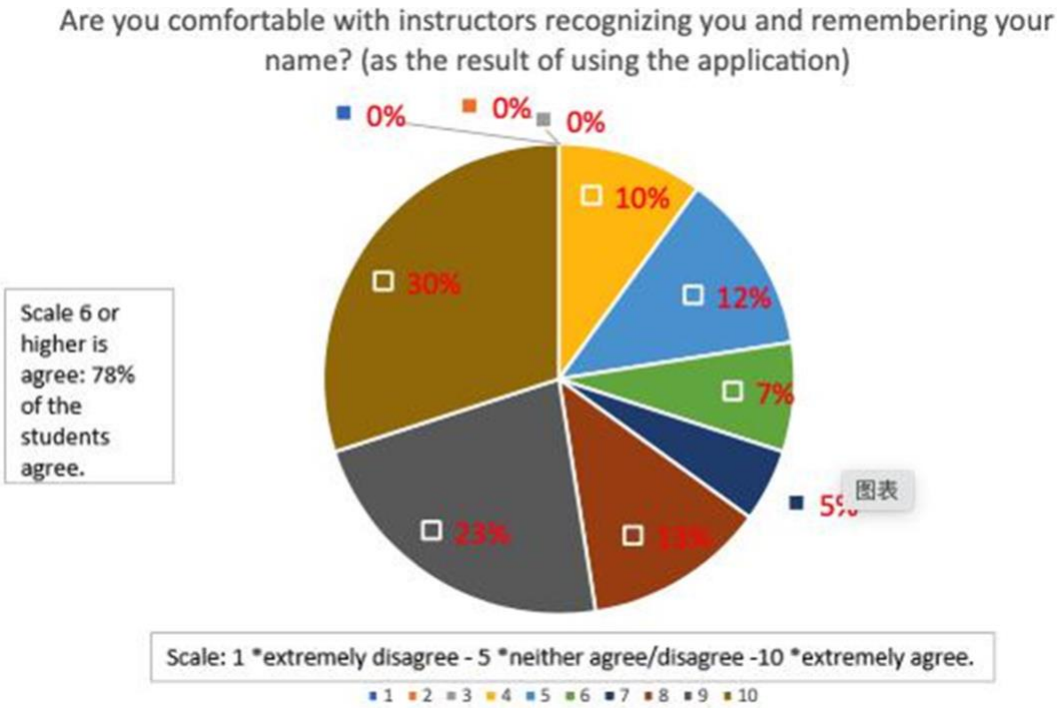


Figure 8: 78% of the students agree with instructors recognizing them and remembering their names.

Appendix C: Average Lecture size

Table 2 provides the average lecture sizes in a few universities in North America [7].
Table 2: Average class sizes.

School	First-and-second year	Third-and-fourth year
Moncton	23.1	14.6
Mount Saint Vincent	29	22.1
St. Thomas	29.5	16.8
Cape Breton	30	23.6
Sherbrooke	30.4	26.8
Brandon	31	13.8
Winnipeg	35.7	18.8
UNBC	35.8	17.4
Laurentian	36.1	18.9
Nipissing	36.2	23.1
Bishop's	36.3	19.6
Regina	38.3	21
UPEI	38.9	16.3
Montréal	39.3	14.8
Lakehead	40.5	26.1
Acadia	41.6	19.3
New Brunswick	42	22
UQAM	42.5	38.9
Laval	42.6	30.4
St. Francis Xavier	43.4	24.6
Memorial	43.6	23.8

Mount Allison	45.8	13.9
Lethbridge	46.3	23.8
Saint Mary's	47.3	22.5
School	**First-and-second year**	**Third-and-fourth year**
Alberta	56.1	24.8
Saskatchewan	58.5	29.8
Concordia	58.6	34.4
McGill	62.2	27.2
Dalhousie	62.8	23.1
Victoria	66.9	26.2
Manitoba	68.5	28.3
Windsor	72.7	34.7
Simon Fraser	75.9	36.9
UBC	80.5	46.5
York	81.1	30
Calgary	81.2	32.4
Trent	81.2	21.4
Queen's	84.3	23
Brock University	88.1	33.4
Wilfrid Laurier	91.8	35.7
Western	92.9	32.9
Carleton	93.3	43.9
McMaster	127.4	51.8
Average	**55.6**	**26.3**