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DRIVING THE FUTURE OF COMPOSITES

COMPOSITES EDUCATION IN CANADA: A SURVEY OF COMPOSITE MATERIALS COURSE OFFERINGS AT CEAB ACCREDITED INSTITUTES

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INTRODUCTION



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- The Canadian composites industry, like many others is facing a wave of retirements^[3]
- 37% of Canadian composites companies respondents identified ‘attracting new (or replacing lost) qualified staff’ was their top priority^[3]
- Many in the composites industry learn on the job and have little to no formal training prior to entering the field
- Many engineering undergraduate students are not aware of the career opportunities with composites when they graduate
- How common and/or available are courses on composite materials in Canadian higher education institutes with CEAB accredited engineering programs?

DATA COLLECTION AND METHODOLOGY



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- Canadian Engineering Accreditation Board (CEAB) lists every accredited institute and engineering program^[5]
 - 46 institutions
 - 305 programs
- The course catalog/calendar for each institution was queried to find reference to the term 'composite' in the course description (graduate level courses also included)
- Courses were categorized according to four attributes:
 - Focus on composites content
 - Type of content
 - Level (undergraduate or graduate)
 - Laboratory component stated in the course description



[5] "Accredited Engineering Programs in Canada | Engineers Canada." Accessed: Jun. 18, 2024. [Online]. Available: <https://engineerscanada.ca/accreditation/accredited-programs>



- Focus on composites content categorized as 1, 2, or 3:
 - Value of 1: Small portion of the course touches on composites
 - Example: 'Introduction to Engineering Materials' course.
 - Covers a wide variety of materials at a high/introductory level
 - Value of 2: Significant composites content but not exclusive to composites
 - Example: 'Polymers and Composite Materials' course
 - Includes courses on specific fields/applications like 'aerospace structures' with a large focus on composites
 - Value of 3: Composites are the main/only focus of the course
 - Example: Fourth-year technical elective 'Introduction to Composite Materials'
 - Courses in this category typically have 'composites' in the course title

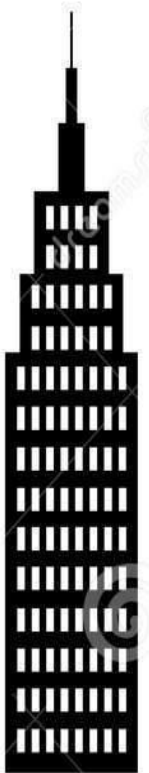
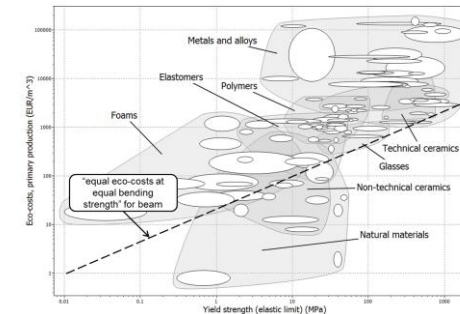
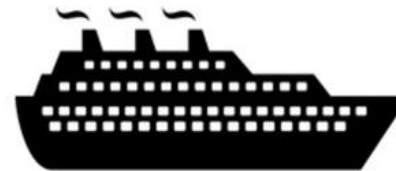
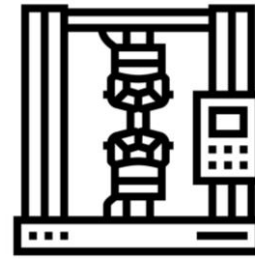
DATA COLLECTION AND METHODOLOGY



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• Courses were classified into one of the following 11 categories:

- Aerospace
- Characterization
- Civil
- Design
- General composites
- Introduction to materials
- Manufacturing/processing
- Marine
- Mechanics
- Material selection
- Wood composites



- The categories were synthesized by examining course descriptions, identifying a category type, then refining once all institutes were surveyed
- Courses were then binned into 'best fit' category

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- The course level was recorded: undergraduate or graduate
- Reference to a laboratory component in the course description was recorded, if there was no mention, then 'not stated' was recorded



- Data collection was done manually over the period of January – June 2024
- Some institutes transitioned from their 2023-24 calendar to their 2024-25 calendar during this time



RESULTS

- A total of 151 courses that had the term ‘composite(s)’ in the course description were identified
 - (in reference to fibre/polymer matrix composite materials)
- A complete data set is available online in CSV format at: <https://compositeskn.org/KPC/A371>
- Now let’s look at a breakdown of the results

Composites Courses at Canadian HEI - A371

Overview

This page provides data on courses that include content on composite materials offered by CEAB accredited institutes in Canada. This data set accompanies the paper *Composites Education In Canada: A Survey Of Composite Materials Course Offerings At CEAB Accredited Institutes* presented by Dr. Casey Keates at CANCOM2024 - 13th Canadian-International Conference on Composites, Waterloo, ON. The data is presented in the table below, as well as in a CSV file for download.

Data collection was done manually by identifying the course listings of the institute and using the search function to find the word 'composite'. This was performed during January - June 2024, which is during the transition between sessions in many institutes. Some institutes transitioned from their 2023-24 calendar to their 2024-25 calendar during this time. Every attempt to collect accurate data was made, however due to the nature of the searching method, time period, wide variety of data presentation conventions, and languages (English, and French) it is possible that some inaccuracies are present and/or out of date at this point in time. If you identify any inaccuracies please feel free to send any comments and/or updates on course information to ckn@composites.ubc.ca.

Abstract from Paper

This page (paper) presents the results of a review of composite materials education in higher education institutes accredited by the Canadian Engineering Accreditation Board (CEAB). Encompassing 46 institutes from all 10 provinces in Canada, data is collected from official course lists provided publicly by each institute. The analysis categorizes course content levels based on the extent of focus on composites (e.g., minor, medium, main focus). Additionally, the paper reports on specific areas of focus, such as mechanics, processing, applications, and material science, the level (undergraduate or graduate) courses are offered, and if there is a laboratory component.

This study aims to shed light on the current landscape of composite materials education in Canada, providing valuable insights for educators, students, and industry professionals. By examining course offerings across accredited institutes, trends, strengths, and potential areas for improvement can be identified and used to prepare the next generation of engineers for successful careers in the composite materials industry.

Data

| Institute | Course Code | Course Name | Level | Laboratory | Field | Focus on Composites | Source |
|---|-------------|--|---------------|------------|---------------------------|---------------------|----------------------------|
| British Columbia Institute of Technology | CHSC 2205 | Engineering Materials 2 | undergraduate | not stated | introduction to materials | 1 | Click Here |
| British Columbia Institute of Technology | CIVL 7022 | Structure and Properties of Materials | undergraduate | not stated | introduction to materials | 1 | Click Here |
| Carleton University | AERO 3700 | Aerospace Materials | undergraduate | yes | aerospace | 2 | Click Here |
| Carleton University | AERO 4608 | Composite Materials | undergraduate | not stated | general composites | 3 | Click Here |
| Carleton University | MAAJ 5107 | Intro to Composite Materials | graduate | yes | general composites | 3 | Click Here |
| Carleton University | CIVE 2700 | Civil Engineering Materials | undergraduate | yes | introduction to materials | 1 | Click Here |
| Concordia University | CHV321 | Engineering Materials | undergraduate | yes | introduction to materials | 1 | Click Here |
| Concordia University | MECH 425 | Manufacturing of Composites | undergraduate | yes | manufacturing | 3 | Click Here |
| Concordia University | MECH 422 | Mechanical Behaviour of Polymer Composite Materials | undergraduate | not stated | mechanics | 3 | Click Here |
| Conestoga College Institute of Technology and Advanced Learning | ENGG 74040 | Civil Infrastructure Rehabilitation | undergraduate | not stated | civil | 1 | Click Here |
| Conestoga College Institute of Technology and Advanced Learning | MATR 73000 | Composite Materials | undergraduate | not stated | general composites | 3 | Click Here |
| Conestoga College Institute of Technology and Advanced Learning | MANU 72025 | Manufacturing Processes | undergraduate | not stated | manufacturing | 1 | Click Here |
| Dalhousie University | CIVL 6156 | Fibre Reinforced Composites for Civil Engineering Infrastructure | graduate | not stated | civil | 3 | Click Here |
| Dalhousie University | MECH 6535 | Fibre Reinforced Plastics | graduate | not stated | general composites | 3 | Click Here |
| Dalhousie University | MECH 3150 | Materials Engineering | undergraduate | yes | introduction to materials | 1 | Click Here |
| Dalhousie University | MECH 6510 | Advanced Mechanics of Solids | graduate | not stated | mechanics | 2 | Click Here |
| Dalhousie University | MECH 4510 | Mechanics of Composite Materials | undergraduate | yes | mechanics | 3 | Click Here |
| Dalhousie University | MECH 6530 | Mechanics of Composites and Smart Structures | graduate | yes | mechanics | 3 | Click Here |
| École de Technologie Supérieure | MEC200 | Technologie des matériaux | undergraduate | yes | introduction to materials | 1 | Click Here |

Understanding Composites Processing

The Knowledge in Practice Centre (KPC) is centered around a structured method of thinking about composite material manufacturing. From the top down, the hierarchy consists of:

- The factory
- Factory cells and/or the factory layout
- Process steps (embodied in the factory process flow) consisting of:
 - Material
 - Shape
 - Tooling & consumables
 - Equipment

The way that the material, shape, tooling & consumables and equipment (abbreviated as MSTE) interact with each other during a process step is critical to the outcome of the manufacturing step, and ultimately critical to the quality of the finished part. The interactions between MSTE during a process step can be numerous and complex, but the Knowledge in Practice Centre aims to make you aware of these interactions, understand how one parameter affects another, and understand how to analyze the problem using a systems based approach. Using this approach, the factory can then be developed with a complete understanding and control of all interactions.

Interrelationship of Function, Shape, Material & Process

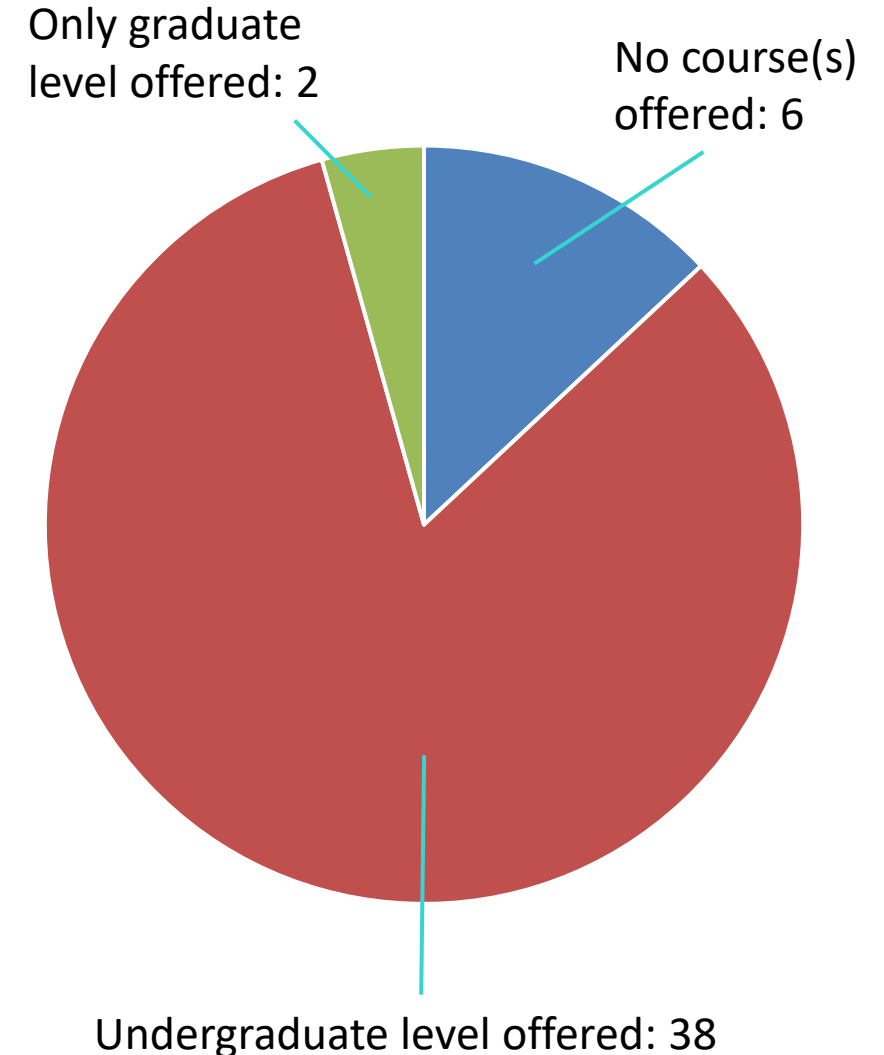
Design for manufacturing is critical to ensuring the producibility of a part. Trouble arises when it is considered too late or not at all in the design process. Conversely, process design (controlling the interactions between shape, material, tooling & consumables and equipment to achieve a desired outcome) must always consider the shape and material of the part. Ashby has

FREQUENCY AND OCCURANCE



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- Majority of institutions, 40 (87%), offer a course with 'composite(s)' in the description
 - 2 of these institutes only offered courses at the graduate level
 - 38 (83%) institutes offered courses to undergraduates
- Six institutes do not offer a course with 'composite(s)' in the course description
 - Of these, five only offered programs that were not likely to be related to composites such as electrical engineering, computer engineering, software engineering, etc.
 - However, one institute offered a mechanical engineering program with no mention of 'composite(s)' in their course descriptions
 - Two institutes only offered graduate level courses

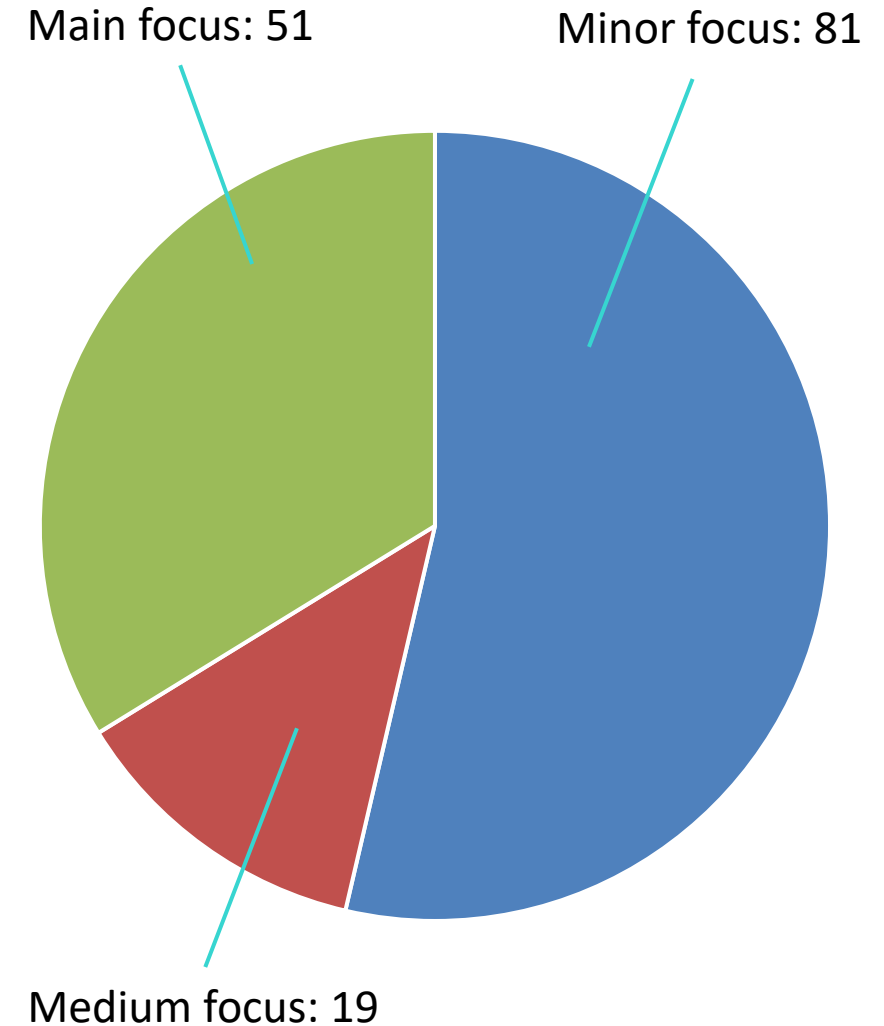


FOCUS ON COMPOSITES



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- Total courses identified: 151
- 81 courses (54%) have a minor focus on composites
 - Mostly 'introduction to materials' courses in second or third year of undergraduate programs
- 51 courses (34%) have their main focus on composite materials
 - Typically technical elective courses with a broad introduction to composites
- 19 courses (13%) have a medium focus on composites
 - Focus on specific applications, e.g., 'aerospace materials'
 - Cover combinations of polymers and composite materials, e.g., 'introduction to polymer and composite materials'.

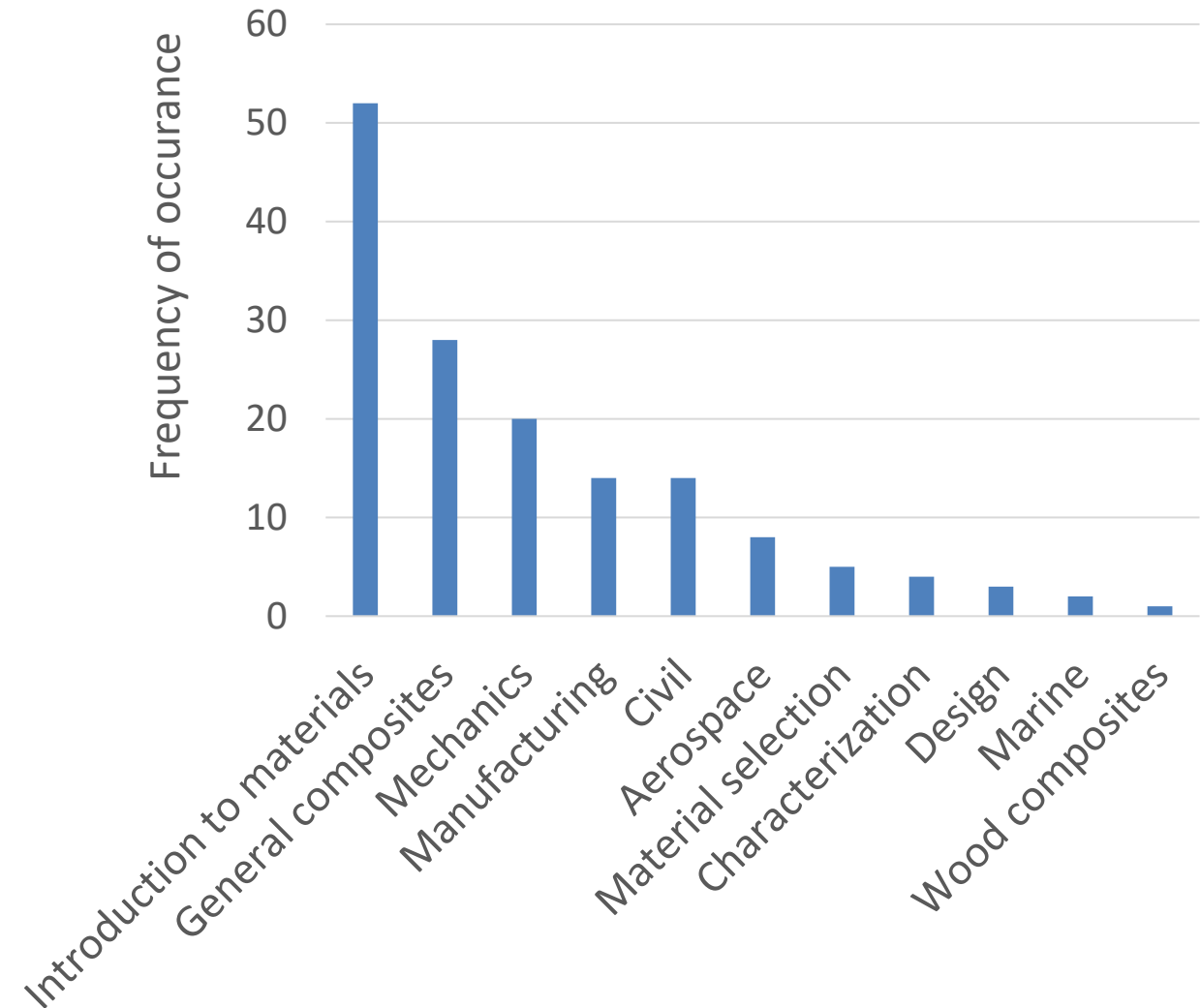


TYPE OF CONTENT



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- The largest category is ‘introduction to materials’, offered by most institutes
 - Includes nearly every course with a minor focus in composites
- The second largest category is ‘general composites’
 - Includes many ‘introduction to composite materials’ technical electives
- Many courses fall into specific fields or aspects, such as:
 - Specific fields: civil, aerospace, marine
 - Specific aspects: manufacturing/processing, mechanics, design



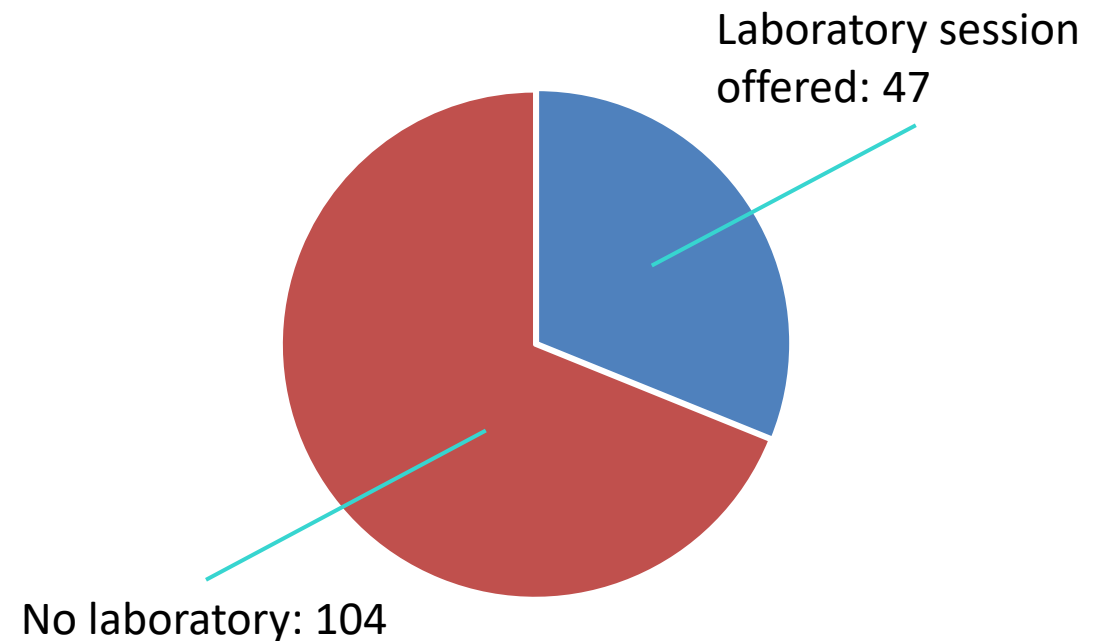
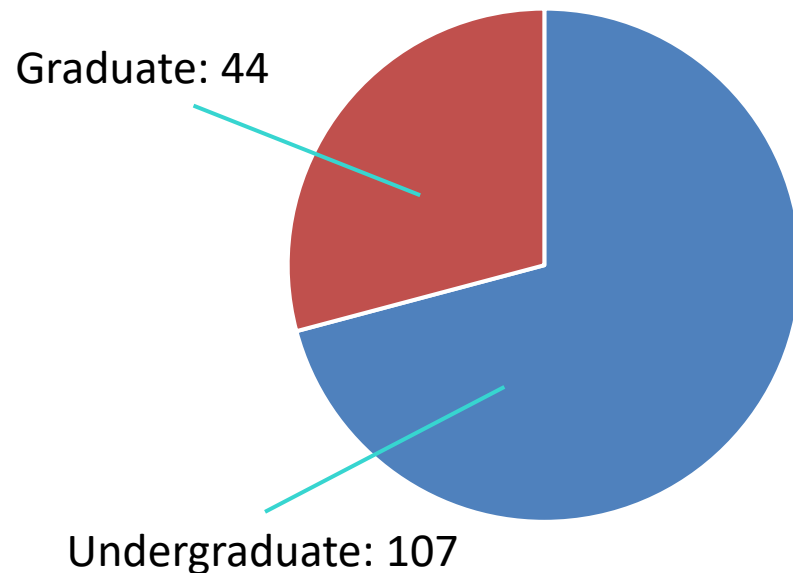
LEVEL AND LABORATORY SESSION



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- Roughly twice as many courses undergraduate level course as grad level
- Major contributors to undergraduate courses:
 - ‘Introduction to materials’ courses (49)
 - ‘General composites’ courses (30)
 - technical elective courses

- Nearly one third of the courses offered include a laboratory session
- Limited and inconsistent information is available regarding student activities in these sessions



DISCUSSION AND CONCLUSION



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- Almost every one of the 46 institutes does offer at least one course that includes the term 'composite(s)'
- However six institutes do not
 - Of these, five only offered programs that were not likely to be related to composites such as electrical engineering, computer engineering, software engineering, etc.
 - However, one institute offered a mechanical engineering program with no mention of 'composite(s)' in their course descriptions
 - Two institutes only offered graduate level courses
- A relatively wide variety of courses that include 'composite(s)' are offered with various levels of focus
 - Most institutes touch on it in their 'introduction to engineering materials' courses
- 51 courses that are focused on composites were found
- 19 courses offer a 'medium focus' on composites
 - Typically present the use of composites in specific applications (ie. aerospace, marine, civil, etc.)
 - This speaks to the significance of composites (ie. we simply cannot ignore composites in aerospace any more)
- In the future, it would be interesting to repeat this study on a program level (ie. materials engineering, or mechanical engineering programs) rather than just on an institute level

REFERENCES AND DATA

- This dataset is available online:
- <https://compositeskn.org/KPC/A371>



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The screenshot displays the 'Composites Courses at Canadian HEI - A371' page on the Knowledge in Practice Centre (KPC) website. The page includes an overview, an abstract from a paper, and a data table. The data table lists various courses from different institutions, including British Columbia Institute of Technology, Carleton University, Concordia University, Conestoga College, and Dalhousie University. The table columns are: Institute, Course Code, Course Name, Level, Laboratory, Field, Focus on Composites, and Source. A QR code is visible on the left side of the page, and a navigation menu is at the top.

| Institute | Course Code | Course Name | Level | Laboratory | Field | Focus on Composites | Source |
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