

Teaching Construction Estimating through a Simulated Student Bid Competition in Canada

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This research paper examines a simulated student bid competition employed in Canadian construction management programs. The Construction Institute of Canada (TCIC), in partnership with industry stakeholders and construction management schools, annually organizes the Canadian Simulated Student Bid Competition (CSSBC) for 3rd year students enrolled in construction management programs across Canada. A key feature of this competition is that it is administered by 4th year students as the bid-calling authority to 3rd year students who compete to prepare the bid. The bid competition is run in accordance with Canadian rules of competitive bidding and industry practices for the duration of an entire semester, allowing it to be integrated into the estimating curriculum as a Capstone estimating project. Through interviews and survey questionnaires, industry stakeholders and academics indicate that the competition provides an applied learning platform for students to display their construction-related hard and soft skills, and exposes them to various roles and responsibilities within the industry. Also, this student-administered Bid Competition model offers hands-on learning experience based on a real-world project and affords opportunities for vertical learning within and outside of the classroom. Feedback from estimating academics indicates that the TCIC bid competition provides an opportunity to authentically assess students with respect to various construction estimating skills.

Key Words: Simulated Student Bid Competition, Construction Estimating, Capstone, Canada

Introduction

Estimating is one of the most important skills required of a professional construction manager (Wei and Sase, 1998; Kirk, 1997) and is defined as the determination of probable construction costs of any given project (Dagostino and Peterson, 2011). Construction cost estimating involves collecting, analyzing, and summarizing all available data for a project (Holm et al., 2005) and there is an art to estimating which can only be mastered through years of practical, hands-on experience (Bender, 2004). Based on the challenges associated with developing an accurate estimate and the relative importance of accurate estimates in the delivery of construction projects, teaching construction estimating effectively requires a well-thought-out estimating curriculum.

Numerous researchers (Jrade and Alkass, 2007; Wei and Sase, 1998) have identified many learning strategies for effective teaching of construction estimating, including computer applications, collaborative learning, team projects, field trips, and student competitions. Student competitions provide an opportunity for students to recognize their strengths and identify areas for improvement (Bolivar and Holt, 2014). With a varying degree of scope and focus, these competitions are typically sponsored by a variety of professional organizations and enable students to work in a team in a collaborative manner to solve a real-world problem (Carns and Plugge, 2017). Student competitions provide a non-traditional learning environment in which students learn by applying their knowledge from their classroom in real world problems (Shim and Xei, 2017). Wankat (2005) provided a summary of a number of studies that have been conducted in relation to the effectiveness of student competitions as an estimating teaching tool. Bolivar and Holt (2014) investigated the benefits of student competitions for their learning experience and their value to construction management education, and other studies have recognized student-perceived benefits from observations and surveys (Schuster et al., 2006).

It is observed that currently, students registered in most US Construction Management education programs have the opportunity to participate in numerous student competitions, including the Associated Schools of Construction (ASC) Student Competitions (Carns and Plugge, 2017; Bender, 2014; Kirk, 1997). Similarly, newly established Canadian Construction Management education programs are looking to participation in simulated bid competitions

as a way of achieving their program learning outcomes. The Construction Institute of Canada (TCIC), which is the educational arm of the Toronto Construction Association (TCA), organizes an annual national simulated bid competition for construction management students in Canadian colleges and universities. This simulated bid competition is not well known outside of Canada for there is no documented peer-reviewed literature published to date on this method of competition. Based on the above, the goal of this research study is to provide an evaluation of a simulated bid competition used as one of the teaching tools for construction estimating in Canadian construction management programs. As such, the specific objectives of this research are to: 1) develop an in-depth analysis of the TCIC's Simulated Student Bid Competition being used as a teaching tool in Canadian construction management programs; 2) analyze the perceived benefits of the Canadian Simulated Student Bid Competition from student, faculty and industry's perspectives, and 3) highlight how participation in the Canadian Simulated Student Bid Competition achieves construction management program learning outcomes as set by the Province of Ontario.

Research Methodology

This investigation's data collection and analysis was done in two parts. The first part of the investigation consisted of an in-depth evaluation of the Canadian simulated bid competition with respect to how it is structured, organized, and integrated into the estimating curriculum of construction management programs, and its perceived benefits. The data was collected by extracting bid competition related information from TCIC's website and numerous other Canadian construction websites, and through interviews with faculty and industry stakeholders, and student survey questionnaires. Seven estimating instructors from various participating schools and nine industry professionals who had direct involvement in this bid competition were interviewed to obtain their insight into the TCIC's simulated bid competition. Their responses supplemented with the data extracted from various websites were used to analyze how the competition was structured, organized and administered, and to analyze the perceived benefits of the competition to schools and the industry. Fourth year students from George Brown College (GBC)'s Construction Management (CM) Degree program were surveyed and their responses were analyzed to obtain their perspective on the perceived benefits from their participation in the previous year's bid competition. Seventy three valid responses were collected from a class of 136 students.

The second part of the research study was completed by identifying the learning outcomes associated with participation in the Canadian simulated bid competition. This was done by analyzing GBC's Construction Management program's courses that were directly associated with the Canadian Simulated Student Bid Competition.

Results and Analysis

Findings of this investigation are presented below and the analysis is developed in three separate subtopics to address the research study's three objectives.

Analysis of Canadian Simulated Student Bid Competition

To document the means and methods of the competition, a structured interview questionnaire was used to obtain responses from estimating faculty from various Canadian construction management schools and industry professionals involved in the Canadian simulated bid competition. Additional information regarding the TCIC's Canadian Simulated Student Bid Competition was gathered from TCIC's website and numerous other construction-related websites. Based on the data collected in this study, it was established that the annual TCIC-administered Canadian Simulated Student Bid Competition is designed to challenge students enrolled in construction management related programs in Canadian colleges and universities from across the country to tackle the bidding and estimating process for a real-world project in the industrial, commercial, and institutional (ICI) sector.

Responses from academics and industry stakeholders indicate that this simulated bid competition is designed to help students tackle the construction bidding and estimating process so they could understand what goes on in the real world of construction. The research findings also indicate that the bid competition allows students to adapt to different situations; shows them what the industry is going to be like; helps them understand the rules of the game, and gets them to showcase their talents.

The basic concept of the bid competition is that teams consisting of four students per team from a 3rd year construction management program submit their bid packages in response to a bid call based on a real-world project with construction drawings, specifications, and other bidding and contract documents. Bidders' complete bid packages containing a bid form, bid form supplements, a bid summary sheet, quantity takeoffs for self-performed work, a subtrade quote analysis and subcontractor selection, a construction schedule, a health and safety plan, and a site mobilization plan. BIM modeling, constructability, and value engineering are also completed but not required to meet the competition requirements.

Submitted bids are tested for compliance and completeness, and are judged based on three mandatory categories: (1) most outstanding professional conduct, (2) most accurate and complete bid package, (3) closest to the target price, and the optional category of BIM production.

Participating Schools

In the 2017 bid competition, there were 93 teams registered for bidding, comprising 349 students from nine schools from across Canada (TCIC, 2017). The research findings indicate that TCIC's Canadian Simulated Student Bid Competition is incorporated into program curricula of most of the participating programs as a Capstone estimating project, and therefore it is mandatory for all construction students to participate.

Industry Collaboration

TCIC collaborates with a wide range of industry partners and construction firms who help support the annual student bid competition. Industry involvement includes monetary contribution, in-kind contribution, supply of industry mentors, fund raising, public outreach, products and services, and industry oversight for the competition (TCIC, 2017). The competition is typically sponsored by more than thirty Canadian construction companies, manufacturers, suppliers, and design firms. Service providers, such as InfiniteSource, Planswift, BlueBeam and RS Means provide free access to their products and services to all competing student teams to support their participation in the competition. In addition, a panel of industry experts are hired by TCIC to ensure the rules of competitive bidding are followed and that industry practices are closely adhered to.

Bid Competition Administration

TCIC, which organizes the Canadian Simulated Student Bid Competition, uses 4th year students from GBC's construction management program to run the competition for all 3rd year students. This responsibility for 4th year students at GBC is also mandatory for completing their construction management practicum course requirements. All fourth year students are required to support the bid committees to which they are assigned for the entire duration of the competition.

TCIC, supported by a panel of independent industry advisors, provides an oversight for the administration of the simulated student bid competition. TCIC's Industry Advisory Panel solicits and secures a complete set of bid documents of an ICI project of \$5M-50M size which is either under construction or a recent build. Through the Expression of Interest process, the Industry Advisory Panel selects a Bid Competition Executive Committee from fourth year student candidates enrolled in construction management programs from colleges and universities across Canada. Once selected, the Bid Competition Executive Committee members elect the Executive Chair to form the bid calling authority to facilitate the competition. The Bid Competition Executive Committee is tasked to manage the preparation of a complete set of bid documents, responses to RFIs, addenda, subcontractor quotes, and administer the competition from beginning to end. The Bid Competition Executive Committee and TCIC's Industry Advisory Panel will evaluate submitted bids and announce winners.

Although the composition of the Bid Competition Executive Committee may vary slightly from one year to another, Figure 1 is a typical organizational structure of the Bid Competition Executive Committee assembled to run the bid competition as the bid-calling authority. The Bid Competition Executive Committee typically consists of multiple committees, including the quantity takeoff (QTO) committee, subcontractor committee, consultant committee,

surety committee, communication committee, mentorship committee, and the industry liaison committee, which are described below.

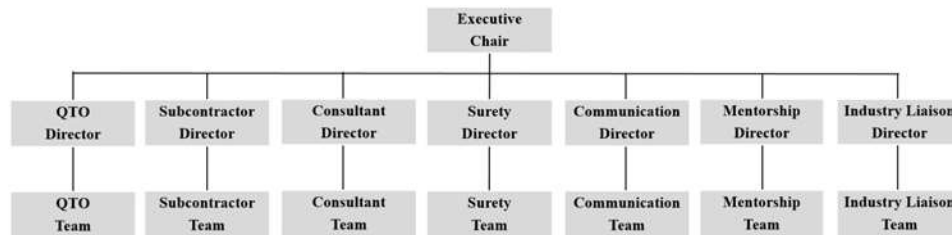


Figure 1: A Typical Organization Structure of the Bid Competition Executive Committee

The Executive Chair is the leader of the Bid Competition Executive Committee and provides overall leadership and management oversight. The Quantity Takeoff (QTO) Committee is responsible for formulating the scopes of work for both self-performed work by Own Forces and subcontracted work, preparing quantities and prices for self-performed work and subcontracted trades as well as expenses for general requirements to build up a target bid price. The target bid price will be used to compare and evaluate bidding teams' bids. The Subcontractor Committee is responsible for preparing the quotes for subcontracted trades and administer subtrade bidding and subcontractor quotation analysis. The Consultant Committee is responsible for managing the issuance of construction documents, including drawings, specifications, RFIs, addenda, contract documents, Instructions to Bidders, and Bid Invitation Letter. The Surety Committee is responsible for issuing surety certificates to bidders, including bid bond and consent of surety for performance bond and labour and material payment bond. The Communication Committee is responsible for team registration, RFI tracking, maintaining the competition website, administration of the Plans Room, and Electronic Bidding, while the Mentorship Committee is responsible for administering industry mentorship for bidders and recruits construction professionals to serve as industry mentors to bidding teams. Finally, the Industry Liaison Committee is responsible for managing relationships with the TCIC management, industry advisors, industry mentors, construction companies, local construction associations, and vendor relations.

Bidding Team Registration Procedure

Each team consisting of four students from 3rd year must register with the TCIC's Canadian Simulated Student Bid Competition Executive Committee by a specified deadline under a fictitious general contracting firm. When registering, all members of each bidding team must sign the confidentiality and non-disclosure contract. Registration, release of bid documents, requests for information (RFI), and addenda are communicated through the Toronto Construction Association (TCA)'s electronic Plans Room. In addition to faculty mentorship, each team must get an industry expert mentor, who must be a practitioner in good standing in the construction industry, to help guide them through the competition period, including pre-bid and post-bid periods. The TCA facilitates the industry mentors to provide guidance to bidding teams during the bidding process. In many cases, the mentorship continues all through the school program and into their professional career after graduation.

Bidding Procedures

The simulated bid competition procedure is summarized in Table 1. The bid committee issues a bid call along with the Instructions to Bidders to all registered teams. This milestone commences the official start of the bid and the bid closing clock is set. The Instructions to Bidders document specifies all the bidding requirements, from bid closing time and location to what is included in the bid package for a compliant and complete submission. It also specifies what work is self-performed and what is subcontracted. Student teams download all bid documents, including the drawings, specifications, contract documents and reports, and begin preparing quantity takeoffs for self-performed work using the Canadian Institute of Quantity Surveyors (CIQS) measurement standard and industry practices. The self-performed work items are priced out from the unit costs obtained from the RS Means Cost Database.

The bid period is generally 8-10 weeks long which is similar to industry standard for competitive bidding. Where bidding teams require additional information or clarifications, RFIs are formally submitted and responses are prepared and released to all bidders in the form of addenda.

The Bid Competition Executive Committee prepares and releases subcontractors' quotes for all subcontracted works. Most subcontractors' quotes are released on the day of bid closing to simulate the real-world bidding. Bidding teams must review the quotes for different trades, analyze them for compliance and completeness, and select a subcontractor for each trade to be carried in their bids. General expenses are costed out, and cash allowances, overhead and profit are added to produce their final bid price.

The bid closes at the time and location specified for each region as indicated in the Instructions to Bidders. Bids are closed at local construction associations' offices across the country in two stages. The first stage of bid closing entails electronic submission of the bid price, a copy of the bid bond, and a work safety insurance certificate. Following 24 hours after the initial bid closing, the second stage requires submission of a hard copy bid package of all the required documents, which include a signed bid form, contract, receipts of addenda, list of carried subcontractors, schedule of alternative prices, construction schedule, site mobilization plan, construction health and safety plan, estimate summary sheet, detailed takeoff sheets and pricing recaps, subcontractors' quote analysis, pricing of general expenses, and any other documents to enhance their submission. Those teams who have selected to participate in the optional BIM production category are required to submit a BIM model, BIM-enabled quantities and schedules, walkthrough visualization, construction schedule, and value engineering.

Submitted bid packages are evaluated by the Bid Competition Executive Committee and the Industry Advisory Panel against the pre-disclosed evaluation criteria using an extensive assessment rubric. Bidding teams are provided with a detailed breakdown of their results and are afforded an opportunity to appeal in the event of disagreements with the Bid Competition Executive Committee's evaluation. TCIC's legal counsel examines and responds to all outstanding appeals. All bids are first tested for compliance and completeness, and are judged for three mandatory categories: (1) most outstanding professional conduct, (2) most accurate and complete bid package, and (3) closest to the target price. The BIM production and analysis category is an optional entry.

Table 1: The TCIC Simulated Student Bid Competition Process

Pre-bid Activities (6 weeks)	TCIC, industry stakeholders and schools meet to discuss planning for bid competition.
	Industry Advisory Panel secures a project and bid documents.
	Industry sponsors are secured.
	Bid Competition Executive Committee is assembled from 4th year students, which forms the bid-calling authority.
	3rd year student teams are invited for bidding and to register with the bid-calling authority.
Bid Period Activities (8-10 weeks)	Bidding teams secure and register their industry mentors.
	A bid call is issued and the bid documents are released. The bid is officially and the bidding clock is set.
	Bidding teams obtain bid documents from TCA's Plans Room and plan out their bidding strategies.
	Bidding teams undertake takeoff and pricing for self-performed work.
	Bid period continues, bidding teams continue their work, RFIs are submitted, and addenda are issued.
	Bidding teams are asked to apply and obtain bond security documents.
	Bid period continues, unit prices for general requirements, profit and overhead percentages are issued.
	Subcontractor quotes are issued in stages. Most quotes are released on the day of bid closing. Bidding teams analyze and select subtrade prices.
	Bidding teams assemble their estimate summary and finalize their bid price.
	Bid closes, bidding teams submit their bid price electronically (1st stage of bid closing)
Post-Bid Activities (2 weeks)	Bidding teams submit their bound bid package (2nd stage of bid closing)
	Submitted bids are tested for compliance and completeness.
	Submitted bids are evaluated by the Bid Competition Executive and Industry Advisory Panel for various categories of competition.
	Competition results are released to all bidding teams. Appeal period is allowed.
	Awards Gala is held and bid competition winners are announced.
	Prizes, cheques and certificates of participation are distributed.
	Bid Competition Executive Committee submits Bid Competition Closeout Report to TCIC and their Industry Advisory Panel.

Analysis of Perceived Benefits of the Canadian Simulated Student Bid Competition from Student, Faculty and Industry's Perspectives

The majority of the academics interviewed indicated that the bid competition allowed students to practice the complete bid process in accordance with the guidelines recommended by CCDC23-A Guide to Calling Bids and Awarding Construction Contracts and using industry standard forms for RFQs, RFIs, Quantity Takeoff, Addenda, Bid Bonds, Bid Forms, and Construction Contract (CCDC2). The results indicate that the competition affords the opportunity to apply learning in an integrated manner instead of a piece-meal approach. The competition also allows students to prepare a detailed bid collaboratively among their peers and promotes networking opportunities in the industry. When the enormity of the task associated with the competition hits them, students appreciate the value of team work as they realize that the success of the project depends upon their respective tasks, which keeps them

motivated to not let the team fail. Most academics made the observation that student outcomes from the competition included better familiarity with the tendering process; applying the relationship between various bid documents; distinguishing between typical scopes of work for general and trade contractors; heightened appreciation of the RFI/Addendum process, and a much improved confidence in tackling what at first blush appears to be a daunting task. A significant, if unanticipated, benefit of the competition, as demonstrated by the findings, is a strengthened relationship between the local contracting community and the student body. By having students exposed beforehand to realistic bidding documents, requiring best estimating practices and simulating the tendering process, one presumes students are better able to ‘hit the ground running’ when they become employed in industry.

Responses from industry practitioners indicate that the Canadian Simulated Student Bid Competition introduces students to various roles and responsibilities within the industry; opportunity to work on an actual project and to experience what it would take to compete; exposure to some of the processes and challenges faced by construction professionals; challenge to test themselves in a controlled learning environment and see how that might compare once in the real world; and exposure to circumstance that cannot be replicated in the classroom. It was also determined that from the industry professionals’ perspective one of the key benefits of this bid competition was that it created a well-trained talent pool for construction companies to use to become more competitive. Their responses indicate that students develop practical skills not only in the technical aspects of estimating and bidding, but also in the soft skills required to overcome challenges of working in Canada’s increasingly ethnically and culturally diverse workforce in the construction industry.

To obtain an insight into students’ perspective on their learning experiences derived from their participation in the bid competition, a detailed survey questionnaire was administered to 4th year construction management students at GBC who competed in the bid competition in 2017. It is this class that will be tasked to administer the bid competition to 3rd year students for the 2018 competition cycle. Figure 2 illustrates students’ perspective on a series of perceived benefits derived from their participation in the bid competition.

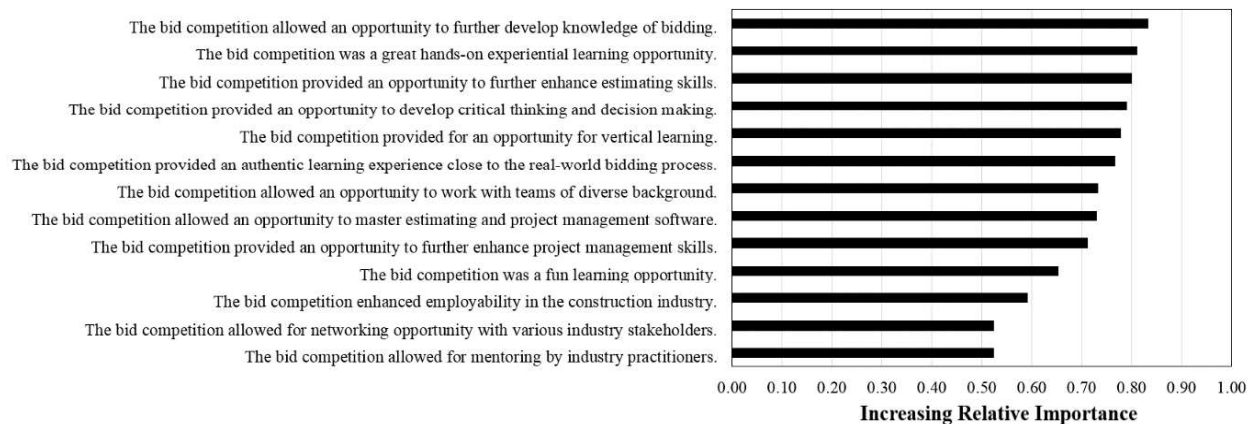


Figure 2: Students’ Perspective on Perceived Benefits of Bid Competition

As it can be seen from the survey results, construction management students who completed the bid competition in the previous year indicated with a high degree of importance that the bid competition allowed them to further develop their knowledge of construction bidding and to further enhance their estimating skills. Results from this survey also indicated that the bid competition was a great hands-on learning opportunity for students which provided them with an authentic learning experience close to the real-world bidding process in the controlled outside-of-classroom environment. Other highly rated perceived benefits reported by students were the opportunities for vertical learning, critical thinking and decision making skills, and mastery of estimating software. Another important observation made from the student survey data was that the bid competition provided students with an opportunity to work with teams of diverse background. Previous research studies have also established that being able to work collaboratively in teams of people with diverse background is a critical skillset required of construction management professionals (Carns and Plugge, 2017; Schuster et al., 2006). Contrary to the feedback obtained from industry participants, it was observed that this study’s student participants appeared to rate the perceived benefit of industry mentorship and industry networking opportunities lower than all other perceived benefits.

CM Program Learning Outcomes Demonstrated through Participation in the Bid Competition

This section of the paper highlights the ways in which Ontario's construction management program learning outcomes are demonstrated by 3rd and 4th year students from George Brown College (GBC) participating in TCIC's Canadian Simulated Student Bid Competition. It must be noted that the focus of this study is not on a detailed quantification of the program learning outcomes and the bid competition, as this will be a topic for future investigation. The Canadian Province of Ontario has established construction management program learning outcomes which must be achieved by its lone Honours Bachelor of Technology (Construction Management) program that is offered by GBC. Student learning outcome compliance is judged by the Bid Executive Committee and the Industry Advisory Panel throughout the bid process, and group members' peer-assessment of their colleagues' performance. Based on the responses from faculty and industry stakeholders, it was determined that this is in fact an authentic assessment of the bid development, submission and award, which mimics how it actually occurs in industry.

Table 2 is a list of the provincially-established construction management program learning outcomes and an indication of their demonstration by 3rd year students who develop the bids as part of their course BLDG3150: Construction Estimating 4 – Cost Control, and by fourth year students who administer the bid competition as part of their course MGMT4053: Practicum in Construction Project Management. The highlighted outcomes are listed in the aforementioned courses and are therefore deemed to be attained by participation in the bid competition.

Table 2: List of CM program learning outcomes and their achievement

Program Outcomes	Outcomes Attained by 3 rd Year Students	Outcomes Attained by 4 th Year Students
1. Use relevant media to communicate all manner of information related to a construction project.	X	X
2. Analyze past performance of projects to predict and improve future projects.	X	
3. Manage projects in a compliant, safe, ethical and sustainable manner.		
4. Apply management tools and concepts in the execution of construction projects.	X	X
5. Recognize and value diversity of opinion, process, and approach.	X	X
6. Incorporate effective leadership strategies to form multidisciplinary and multicultural teams and work groups.	X	X
7. Use the theories and practices of organizational behavior and human resources to manage and develop people.		X
8. Model and analyze technical problems by applying sound engineering and building science principles.		
9. Assess and apply business, accounting and financial principles.		
10. Assess and apply logistical concepts and practices in the management of time, cost and quality performance.		
11. Evaluate risk potential and environmental impact of projects and mitigate accordingly.		
12. Create technical documents such as tenders, RFPs, records, etc.	X	X

Of the 12 program learning outcomes, six of them are demonstrated by 3rd students as they participate in the bid competition. These students demonstrate an ability to use relevant media in the form of a bid to communicate construction information, analyze past cost information and production rates to predict or estimate costs, apply various estimating tools and concepts in developing their bids, exchange opinions and have discussions as a team with respect to their bid development, and lastly, employ leadership strategies in the formation and functioning of their bidding teams. The 4th year students, who are responsible to administer the bid competition as the bid-calling authority, also demonstrate abilities in attaining six of the program's learning outcomes. While five of these outcomes are the same as those demonstrated by the 3rd year students, the sixth outcome that is demonstrated is the ability to apply human resource and organizational behavior theories in the administration of the bid competition. In essence, as the bid-calling authority they must function like an organization that is procuring construction work requiring students to demonstrate leadership and organizational management skills, including conflict management.

Conclusions and Future Research

Findings indicate that TCIC's Canadian Simulated Student Bid Competition is the only such competition in Canada and it does provide a means by which to expose and authentically assess students with respect to various skills associated with construction estimating. Through the participation of industry practitioners as mentors and competition judges, students are likely to gain a better appreciation of the expectations that will be placed on them as they prepare to enter the industry. Based upon the findings of this investigation, the following conclusions can be made:

1. The Canadian Simulated Student Bid Competition as an estimating teaching tool is designed to simulate the challenges of estimating and bidding as they are encountered in the real world.
2. The competition is a great platform for Canadian construction management students to display their skills, and appears to be a source of talent that construction companies can continue to hire year after year.
3. One of the key characteristics of the Canadian Simulated Student Bid Competition is that this competition is run for the duration of an entire semester and it is administered by 4th year CM students for 3rd year students. As an instructional tool, this competition offers opportunities for vertical learning.
4. Participation in this student bid competition model allows various program learning outcomes to be attained by both 3rd and 4th year CM students. Students appear to develop practical skills not only in the technical aspects of estimating and bidding, but also in the soft skills required to function in a group.

The following are three recommendations for future research which, when completed, will provide a better understanding of the effectiveness of the Canadian simulated bid competition. Firstly, an in-depth quantitative analysis of CM learning outcomes and the Canadian Simulated Student Bid Competition is needed to better understand the extent to which CM learning outcomes are being achieved. This will form a basis on which to revise the way in which the bid competition is implemented. Secondly, an assessment of the soft skills and competencies gained through participation in the TCIC's Canadian Simulated Student Bid Competition is needed to provide quantitative measures of the attainment of various skills and competencies. These measures can then be used to benchmark the soft skills and competencies of CM students over time. Thirdly, an investigation into the extent to which vertical learning occurs through participation in the TCIC's Canadian Simulated Student Bid Competition must be done. This will help to provide a better understanding of the effectiveness of the way in which the competition is structured and administered with respect to promoting student learning.

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