Hydrographic Surveying Subject Design and Development Aspects at a Canadian University

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Key words: graduate attributes, learning outcomes, assessment items, international standards, rigorous calibration of a single beam echo sounder

SUMMARY

This paper introduces the reader to two hydrographic surveying related subjects (i.e., three credit hour courses) in a geomatics engineering program at a Canadian university. The paper has two main objectives. The first objective is to share some of the design and development experiences of the course instructor with other geomatics engineering or land surveying instructors and/or hydrography enthusiasts. The design and development of these courses is performed with the theoretical framework of Bloom's taxonomy in mind. That is, all learning outcomes are written using action verbs with a well-rounded distribution between the different cognitive levels, i.e., remembering, comprehending, applying, analyzing, evaluating, and creating. Since the degree program is accredited by both an engineering and a surveying national boards, some of the major accreditation requirements for the courses are explained. These, for example, include measuring graduate attributes and aligning course content with a list of prescribed topics. A modern teaching practice, i.e., team-based learning, is discussed, and an example of in-class exercises following the team-based learning scheme are illustrated.

The second objective of the paper is to provoke a discussion on the practical aspects of running a rigorous plate check calibration as part of a hydrographic surveying exercise in a typical geomatics engineering field school. The mapping portion of a body of water of interest is performed using a single beam echo sounder mounted on a remotely controlled mini catamaran. Some of the issues in preserving the rigour, achieving a desired accuracy, and maintaining the safety of the students during the calibration are expressed. For example, the type of calibration platform, the way the remotely controlled mini catamaran is docked at the platform, the options for suspension mechanism, and the number of contact points with the calibration plate are discussed. At the end of the paper recommendations are provided on how to develop such an exercise given the most current experiences of the course instructor and his team in designing and testing the equipment at hand.

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1. INTRODUCTION

This paper addresses subject (i.e., three hour course) design and development aspects related to hydrographic surveying in a geomatics engineering program at a Canadian university. In the program in question, there are primarily two courses which contain hydrographic surveying content. One of the courses tackles most of the hydrographic surveying theory, while the other course provides rudimentary practical experience in hydrographic surveying. The theory course is a fourth-year technical elective. It is one of four required technical electives for students wanting to graduate with the cadastral concentration. The cadastral concentration fulfills the educational requirements for individuals planning on pursuing the land surveying profession in most of the jurisdictions in Canada. The practical course is a field school, also known as 'survey camp', for all students just before the last year in their degree program. In this course, students are required to complete eight major exercises in groups. The hydrographic surveying exercise is one of the major exercises. Note that neither of the two courses are International Federation of Surveyors (FIG) / International Hydrographic Organization (IHO) / International Cartographic Association (ICA) S-5 / S-8 Category A or B recognized training as described by the International Board on Standards of Competence for Hydrographic Surveyors and Nautical Cartographers (IBSC) (2017), i.e., they are meant for geomatics engineers and land surveyors, not international hydrographers. Also, the reader can refer to Forrest (2003), Suebe et al. (2012), Coutts and Strack (2012), and de Wulf et al. (2013) for other perspectives on hydrographic education.

The paper has two main objectives. One is to share some of the design and development experiences of the course instructor with other geomatics engineering or land surveying instructors and/or hydrography enthusiasts. For that purpose the paper first explains the theoretical framework of the main author, and the external requirements of the surveying and engineering national accreditation boards, considered when designing and developing the hydrographic surveying courses within the geomatics engineering program. The paper also lists the chapters covered in the theory course in addition to its learning outcomes and assessment items. Moreover, ideas are provided for the delivery of some of the course content in an active learning (Prince, 2004) style, inspired by team-based learning (TBL) (Michaelsen et al., 2004). According to Prince (2004) active learning includes teaching and learning activities where students are intellectually engaged beyond passively listening to a lecturer and mechanically writing notes. Such activities may include think-pair-share, using clickers, or writing minute papers. Team-based learning is definitely classified as a set of active learning activities. In TBL students are asked to read certain material before coming to class, then they are quizzed on it individually, and right after that they tackle the same quiz in groups of three to five students. Any misconceptions on the material are addressed in the form of a mini lecture after both the individual and the group quizzes have been graded. The TBL cycle on the particular material culminates in assigning the students a complex application where they have to come up with a solution in groups.

The second objective of the paper is to provoke a discussion on the practical aspects of running a rigorous plate check calibration for a remotely controlled surface vessel equipped with a single beam echo sounder. In particular, the hydrographic surveying exercise in the field school, where a plate check calibration is a major component, is described. Options for conducting the exercise with students for educational purposes are given to the reader so that the exercise can be run with rigour, accuracy, and safety in mind. Note that the survey camp exercises are run such that real-world experience is mixed with learning or fortifying concepts, problem solving / trouble shooting, and self-reflections (Stice, 1987). In other words the course instructor strives towards creating an environment for experiential learning (Abdulwahed and Nagy, 2009). Lastly, recommendations are drawn for the continuous improvement of students' learning experiences in both courses.

2. THEORETICAL FRAMEWORK

The majority of the courses in the geomatics engineering program contribute to the engineering and/or the surveying accreditation of the department. As such they must fullfill the program outcomes imposed by the engineering and/or surveying national accreditation boards. The two hydrographic surveying related courses mentioned in the introduction must for example abide by both accreditation bodies. However, before jumping into how those accreditation constraints shape the design of the courses, it is worth exploring a more general theoretical framework. The theoretical framework that can be used in the design of most engineering and surveying courses is Bloom's taxonomy (Bloom, 1956), especially the version of the taxonomy modified by Krathwohl (2002). The taxonomy clasifies learning tasks on a cognitive spectrum from remembering (the lowest level, i.e., implying primarily memorizing facts) to creating (the highest level, i.e., implying a great deal of critical thinking). Each of the six levels in the hierarchy comes with a set of action verbs (see Table 1). These action verbs are recommended to be used for lesson planning, development of laboratory exercises, and in general – coming up with learning outcomes for an entire course or a course component. A well-rounded course will contain learning outcomes, teaching and learning exercises, and course assessment items covering the entire range of congnitive levels (if possible and/or applicable). For example, if a course only contains definitions, simple concepts, and one-step formulae, students are probably only challenged at the lower congnitive levels, and it may be a good idea to introduce outcomes that provoke critical thinking. Conversely, if a course expects students to analyze complex results, evaluate multiple routes to a complicated solution or even create new knowledge or a product, it would be expected that the instructor scaffolds the process with more basic tasks at the beginning, and the higher order tasks culminate towards the end. Note that the action verbs listed in

Table 1 are meant as examples only. It is quite possible that depending on the context certain action verbs may be catagorized under more than one of the six cognitive levels.

Table 1. Hierarchy of the cognitive levels in Bloom's taxonomy, and examples of action verbs appropriate for engineering and surveying for each level

Order in hierarchy	Cognitive level	Example action verbs
6.	Creating	Design, develop, modify, generate, invent
5.	Evaluating	Check, interpret, criticize, decide, refine/revise
4.	Analyzing	Identify, differentiate, select, correlate, conclude
3.	Applying	Use, compute, solve, implement, demonstrate
2.	Comprehending	Summarize, classify, compare, contrast, discuss
1.	Remembering	Recall, list, define, describe, explain

3. ACCREDITATION REQUIREMENTS

There are two nation wide bodies that accredit the geomatics engineering program at the department. One is the Canadian engineering accreditation board (CEAB), and the other one is the Canadian board of examiners for professional surveyors (CBEPS). Some of the major accreditation requirements for each of the organizations are explained in the next two sub-sections.

3.1 Engineering accreditation

The engineering board takes a holistic approach to accreditation. Each degree program is evaluated as a whole where a certain number of accreditaiton units must be approved, and a prescribed list of graduate attributes must be achieved. Each course in the program contributes to the total number of certain accreditation units and the measurement of certain graduate attributes. The accreditation units correspond to content and are binned into the following high level categories: mathematics, natural sciences, engineering science, engineering design, complementary studies, and other unspecified content. The graduate attributes can be viewed as high level learning outcomes. There are 12 graduate attributes, and each can be measured as introduced (I), developed (D), or applied (A): 1) Knowledge base for engineering; 2) Problem analysis; 3) Investigation; 4) Design; 5) Use of engineering tools; 6) Individual and team work; 7) Communication skills; 8) Professionalism; 9) Impact of engineering on society and the environment; 10) Ethics and equity; 11) Economics and project management; and 12) Life-long learning (Engineers Canada, 2016).

Currently, each of the learning outcomes listed in the outline for a particular course must be mapped to a single graduate attribute. Each of the learning outcomes must be assessed in ideally two or more graded items (e.g., exam questions, laboratory assignments) or other teaching and learning activities. Essentially assessing students' performance for specific learning outcomes counts as measuring their achievement level for the corresponding graduate atrributes. A certain percentage (70-75%) of the students in a particular course must perform at a satisfactory level for each of the measured graduate attributes. If this is not the case for a certain graduate attribute, the instructor is asked to devise a plan of improving the course at its next iteration.

3.2 Surveying accreditation

The surveying board of examiners takes a much more detailed approach to accreditation. They prescribe content topics, sub-topics, and learning outcomes for 12 core and five elective subjects (CBEPS, 2019):

- C1 Mathematics; C2 Least Squares; C3 Advanced Surveying; C4 Coodinate Systems and Map Projections; C5 Geospatial Information Systems; C6 Geodetic Positioning; C7 Remote Sensing and Photogrammetry; C8 Cadastral Studies; C9 Survey Law; C10 Land Use Planning and Economics of Land Development; C11 Business Practices and the Profession; and C12 Hydrographic Surveying
- E1 Spatial Databases and Land Information Systems; E2 Advanced Hydrographic Surveying; E3 Environmental Management; E4 Advanced Remote Sensing; and E5 Advanced Photogrammetry

Normally, it takes at least one to two university courses to satisfy the requirements of each subject. The subjects related to hydrographic surveying are: C12 Hydrographic Surveying (core subject), and E2 Advanced Hydrographic Surveying (elective subject). While some of the E2 topics are also taught, the focus in this paper is on C12 as it is the subject accredited at the department. Table 2 lists the topics and sub-topics required for the core hydrographic surveying subject. Note that each of the sub-topics comes with one or more low level learning outcomes. They are numerous and it is not practical to list of all of them in this paper. However, it is worth mentioning that their approximate distribution among the Bloom’s taxonomy categories is the following: 50% in remembering; 15% in comprehending; 8.5% in applying; 14% in analyzing; 11.5% in evaluating; and ~1% in creating.

4. COURSE DESIGN AND DEVELOPMENT

This section of the paper describes some of the design and development of the two hydrographic surveying related courses in the department. The first sub-section addresses the theory course, while the second sub-section addresses the hydrographic surveying exercise in the field school.

4.1. Hydrographic surveying theory

The accreditation units assigned to the theory course in hydrographic surveying are 70% engineering science and 30% engineering design. The learning outcomes found in the course outline are listed in Table 3. Their corresponding graduate attributes and cognitive categories from Bloom’s taxonomy are also shown. Note that the learning outcomes are mapped to six out of the 12 graduate attributes, and that they cover the entire cognitive spectrum.

Table 2. Topics and sub-topics for hydrographic surveying as per the board of examiners for professional surveyors

#	Topic name	Sub-topics
1.	Underwater acoustics	Acoustic velocity Sound wave propagation Acoustic system parameters
2.	Single beam echo sounders (SBESs)	Transducers; Data recording Sounding reduction Sounding accuracy (or error budget) System selection; Equipment evaluation
3.	Multibeam echo sounders (MBESs)	Multibeam transducers Coverage and accuracy (or error budget) MBES calibration Importance of time & motion MBES data management; Equipment evaluation
4.	Side scan sonars (SSSs)	Side scan sonar systems Side scan sonar data interpretation SSS vs MBES System selection; Equipment evaluation
5.	Tide and non-tidal water levels	Tidal fundamentals; Tidal measurements Tidal streams and currents; Tidal information Non-tidal water level variations
6.	Vertical positioning	Previous datums; Datums Vertical datum fundamentals Elevation measurements and computations Heave; Orientation
7.	Understanding of principles and technology	Instrumentation; Operations Survey data processing
8.	Hydrographic surveys	Surveys in support of river crossings and engineering Surveys in support of port management and coastal engineering Nautical charting

The assessment items used in measuring students’ graduate attribute achievements are primarily conceptual and calculation questions from the exams (two midterms and a final), and portions of the laboratory assignments. Note that in-class exercises inspired by team-based learning (TBL) are also included. For example, the in-class exercises are related to the international standards in hydrographic surveying and the design of a survey that will meet specifications for a particular project / scenario. More specifically, the students are asked to read the ”IHO Standards for Hydrographic Surveys” special publication No. 44 (a.k.a. S-44) by the International Hydrographic Bureau (IHB) (2008). The individual and group quizzes are run on the content of this document. At a later date, after the quizzes have been marked and the mini lecture clarifying any misconceptions has been conducted, the students are given the application. The application is based on real life projects (e.g., charting a dam reservoir, harbour dredging, offshore construction). The students need to design a hypothetical hydrographic surveying solution which will have to abide by the international standards (if applicable) and also meet the client's specifications. Anecdotally, students have shared with the instructor that "this is a different type of learning," and that they have enjoyed what would have otherwise been a mundane task.

Table 3. Learning outcomes for the theoretical hydrographic surveying course, their corresponding graduate attributes and cognitive categories in Bloom's taxonomy

#	Learning outcome	Graduate attribute	Category in Bloom's taxonomy
1.	Explain theoretical concepts (and their relevance in hydrographic surveys) related to oceanography, tides, water levels, and underwater acoustics	1 (I)	1-2
2.	Develop algorithms for hydrographic applications such as predicting tide, determining a precise depth, and acoustic ray tracing	2 (D)	3
3.	Apply sonar parameters and equations for the prediction of performance and the design of echo sounding equipment	2 (D)	3
4.	Recognize, interpret, and adapt international standards for hydrographic surveying for the purpose of safety of marine navigation	8 (I)	2, 5
5.	Design single beam (in conjunction with side scan sonar), multi-transducer boom, and multi-beam echo sounder surveys so as to meet international standards and/or client specifications	4 (D)	6
6.	Choose between various options for horizontal, vertical, 3D marine, and/or underwater acoustic positioning for different hydrographic operations	5 (D)	5
7.	Perform echo sounder calibrations in order to mitigate system errors: plate check for single beam and patch test for multi-beam data	3 (A)	3-4
8.	Process hydrographic surveying data with state-of-the-art software in order to generate a bathymetric chart	5 (A)	3, 6

The chapters in the hydrographic surveying theory course are listed in Table 4. Table 4 also shows how these course chapters map approximately to the topics and sub-topics prescribed by the board of examiners for professional surveyors. Note that there is not always a one-to-one relationship between the two lists.

4.2. Hydrographic surveying practice

While the theoretical course has a laboratory component, most of the assignments have to do with implementing algorithms and processing hydrographic surveying data that is provided to the students. There is value, however, for the students to also collect and process their own data. This happens during the hydrographic surveying exercise at survey camp. The next two sub-sections describe the hydrographic surveying exercise and list some of its implementation challenges.

Table 4. Course chapters and the equivalent topics as prescribed by the board of examiners for professional surveyors

#	Course chapter	Corresponding topic(s) by the board of examiners for professional surveyors
1.	Elements of oceanography	N/A
2.	Tides and tidal currents	5
3.	Coordinate systems and datums	6
4.	Underwater acoustics	1
5.	Types of hydrographic surveys and specifications	8
6.	Marine positioning	N/A
7.	Sounding methods	Most of 2, 3, 4, and 7
8.	Acoustic positioning concepts	N/A
9.	Hydrographic survey design and assessment	2 (sounding accuracy / budget and system selection) 3 (coverage and accuracy) 4 (data interpretation and system selection) 7 (survey data processing)

4.2.1 Overview of the hydrographic surveying exercise at survey camp

The goal of the hydrographic surveying field exercise is to create a reasonably accurate bathymetric chart of a portion of a dammed lake. The shoreline survey is performed via a real time kinematic (RTK) global navigation satellite positioning system (GNSS) unit. The vertical positioning is established via differential levelling between a land surveying bench mark and the water level. The actual lakebed mapping is achieved via a remotely controlled mini catamaran (a.k.a. a HyDrone by Seafloor Systems Inc. (2019a); see Figure 1a). An RTK pole is mounted on the HyDrone with a GNSS rover antenna and a HydroLite-TM single beam echo sounder (SBES) transducer coupled together (Seafloor System Inc., 2019b). The rover antenna is screwed to the top of the pole in order to provide the horizontal positioning of the vessel, and the transducer is attached to the bottom of the pole in order to provide the depths of the lake bed (see Figure 1b). The technical specifications for the HydroLite-TM are listed in Table 5.

In order to reduce the acquired depths to a sounding datum, the draft of the transducer and the scaling factor for the speed of sound in water must be known. A plate check calibration is the rigorous way of estimating these parameters (US Army Corps of Engineers, 2013). The idea behind such a calibration is that a large target, i.e., a plate, is suspended at known depths below the transducer. The known depths are incremented at equal intervals, e.g., 1 m. At each of the known depths several SBES observations are recorded. A curve, e.g., a straight line, is fit to the data where the echo sounding observations, d^{ES}, are on the x-axis and the known depths, d^{known}, are on the y-axis. The y-intercept of the line, b, is the draft of the transducer (technically – the combined effect of the draft of the transducer and the system zero error), and the slope of the line, m, is the scaling factor for the speed of sound in water:

$$d^{known} = md^{ES} + b$$


(a) (b)

Figure 1. HyDrone performing mapping of a lake bed (a); a close-up of the HyDrone before deploying

Overall, students get to integrate different technologies to achieve vertical and horitontal positioning for their soundings, they get to clean up the data set they have collected from outliers, they get to implement least squares estimation and statistical testing for a hydrographic surveying application, and most importantly they end up generating their own first hydrographic surveying product. Both the data collection and the post processing procedures include tasks that need to be completed both individually and in a team.

Table 5. HydroLite-TM technical specifications

Parameter	Value
Frequency	200 kHz
Beam width	4-9°
Ping rate	6 Hz with 2 Hz output
Depth accuracy	1 cm / 0.1% of depth
Range	0.3 m – 75 m
Approximate cost	\$7,766 CAD (SonarMite only) \$9,558 CAD (entire HydroLite kit)

4.2.2 Implementation options for a plate check calibration

Acquiring accurate data for the plate check calibration of the HyDrone in a safe and reasonably straightforward manner, however, comes with several practical challenges. A few options must be considered for the implementation:

- the type of platform: a fishing boat vs. a two-canoe catamaran
- the way of docking the HyDrone next to the platform: ropes vs. a special contraption
- the suspension mechanism for the plate (if any): manual vs. a winch; and
- the way the plate is being held by the suspension mechanism: using one rope (with four points of contact) vs. using two ropes (with two points of contact each).

Since the department does not own a vessel, the calibration platform can be a fishing boat (see Figure 2a) or a two-canoe catamaran (see Figure 2b) as both boats and canoes can be readily rented. The advantage of a rental boat is that it comes in a package with a trailer and an outboard engine. The boat can support both the engine (on the stern) and the suspension mechanism / docking station (on the starboard for example). However, it is very heavy if it needs to be launched manually, and it is prone to rolling. In past course evaluations, students have complained about having to manually launch the heavy boat. The advantage of the two-canoe catamaran is that it is much lighter and a lot more stable, and it can potentially handle more passengers. However, a third-party frame is necessary to connect the two canoes, and rowing or an electric trolling motor is required. Also, transporting more than one rental canoe at a time to a lake is not a trivial task.


(a) (b)

Figure 2. Options for a calibration platform: a fishing boat (a), and a two-canoe catamaran held together by an aluminum frame

In case the platform is a fishing boat, the HyDrone can be kept in place next to the (starboard) hull by tying it to a cleat or clamps mounted on the gunwale (see Figure 3a). If the platform is a two-canoe catamaran a special contraption can be built in between the bows of the canoes (see Figure 3b).


(a) (b)

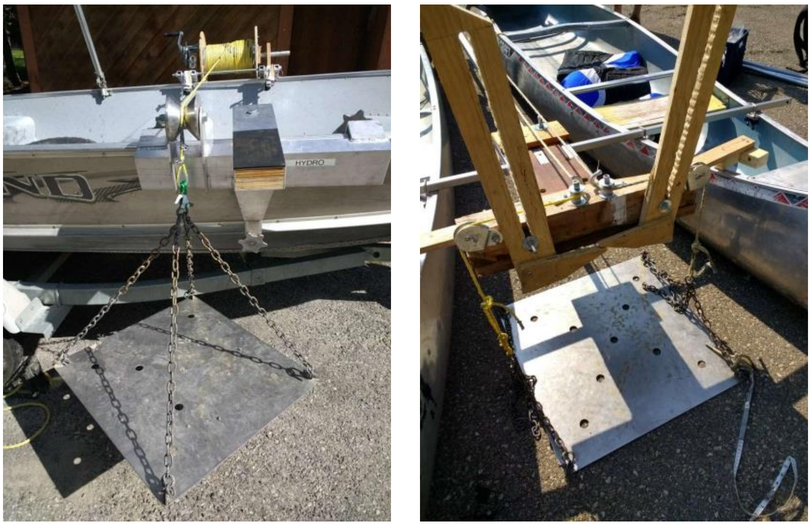
Figure 3. Options for docking the HyDrone next to the calibration platform: tying it with ropes (a), and building a custom contraption

Manually suspending and lifting the calibration plate with a rope through a pulley (see Figure 4a) is simpler than having an actual mechanism, but it is not preferred as it is not as accurate and could potentially be unsafe for the operator. Also, over the years students have anecdotally mentioned how manually suspending the plate is tiring, it requires gloves, and often it can only be done by someone with strong hand grip and physical endurance. One may argue that such a physical challenge may be a distraction from the actual exercise. The ideal mechanism is a winch with a gear reduction system, an option for locking the gears, and a spool for collecting the rope(s) (see Figure 4b).

(a) (b)

Figure 4. Options for a plate suspension mechanism: manual suspension via a pulley (a), and a custom-made gear reduction winch system with a spool

Having all four corners of a metal plate chained to a single rope, i.e., a single quadruple point of contact (see Figure 5a), is simple, but the chains or the rope could potentially be in the way of the acoustic signal and thus causing multipath effects. Having two of the plate corners chained to a rope, and having the other two corners chained to another rope, i.e., two pairs of contact points (see Figure 5b), should theoretically prevent the acoustic signal hitting the chains or the ropes, but spooling two ropes at an equal rate and keeping the plate levelled becomes complicated. In either case the rope / ropes must be precisely graduated.



(a) (b)

Figure 5. Options for holding the calibration plate: single point of contact (i.e., one rope) (a), and two points of contact (i.e., two ropes)

5. DISCUSSION ON THE COURSE DESIGN AND DEVELOPMENT

5.1 Theory course

Measurement of graduate attributes is a time consuming task. It is, however, a required task by the engineering accreditation board, and also could be used as an opportunity to flag essential assessment items / learning outcomes related to students' unsatisfactory performance. Usually, students perform better at assessment items from laboratory exercises and homework compared to exam questions. This is why it is important to perform course design alignment, i.e., set clear expectations / share course level and chapter level learning outcomes with the students, perform teaching and learning exercises during the contact hours that address these learning outcomes, and assess students' mastery of the outcomes in laboratory exercises and exams (Biggs, 1996).

Aligning the course content with the topics prescribed by the board of examiners for professional surveyors is also a time consuming, but rewarding task. It is crucial for the study material presented to the students to be up-to-date and relevant to the hydrographic surveying industry.

5.2 Survey camp exercise – instructor's perspective on the calibration options

Providing the students with boat time where they get to collect and process their own SBES data is also an invaluable learning experience. Many of the students end up having desk jobs or jobs related to geomatics engineering sub-disciplines other than hydrographic surveying, so this is their chance to get first hand experience wrestling with problems in field work on water.

In terms of the different options for implementing a rigorous plate check calibration for a HyDrone, in theory it would be best to use a two-canoe catamaran with a special contraption for the HyDrone, a winch, and two ropes for suspending the plate. Here are some issues that may come up in practice though. The third-party frame holding the two-canoe catamaran together must be tested with a variety of canoes. While it works with most types of canoes, it fails to work with canoes which do not have a large enough lip on the gunwale. Also, having students row from the shore to the calibration location may be a time consuming and frustrating task. Renting an electric trolling motor may or may not be an option depending on the local venues. Building a contraption for the HyDrone to stay in place during the calibration is a good idea, but sometimes it may be necessary to release the HyDrone and shift it horizontally so that it is better positioned over the plate. Having a winch with a gear reduction system is definitely helpful especially when lifting the plate. However, an off-the-shelf unit ready to be used for this application is not available (at least the authors have not been able to find one), so some customizing must be done.

Finally, one of the most frustrating dilemmas is the use of a single rope vs the use of two ropes for holding the calibration plate. Initially, a single rope was used for simplicity, but that seemed to cause systematic issues in the distance returned by the SBES at depths of ~1-7 m. The hypothesis was that the beamwidth is narrow enough that at short range the acoustic beam may hits the chains first instead of the actual plate. The two rope system was designed such that theoretically the chains and the ropes would not be in the way of the signal at least at short range. Unfortunately, at least with this specific SBES, this was not the case. The returned distances again exhibited systematics errors much larger than the expected random error listed in the instrument specifications by the manufacturer. For example, Figure 6 shows two plate check calibration sets acquired in a swimming pool at an approximate depth of 3.5 m. One of the data sets was collected with two ropes and the other one with a single rope. The range of depths for each plate position for the single rope data is about 30-50 cm, which can be attributed to the chains connecting each of the plate corners to the rope. The data set collected with two ropes clearly exhibits much greater error, often approximately double the distance that should have been observed. Thus, it is recommended to revert back to a single rope use instead of complicating the suspension mechanism in trying to spool two ropes at an equal rate in order to keep the calibration plate levelled.

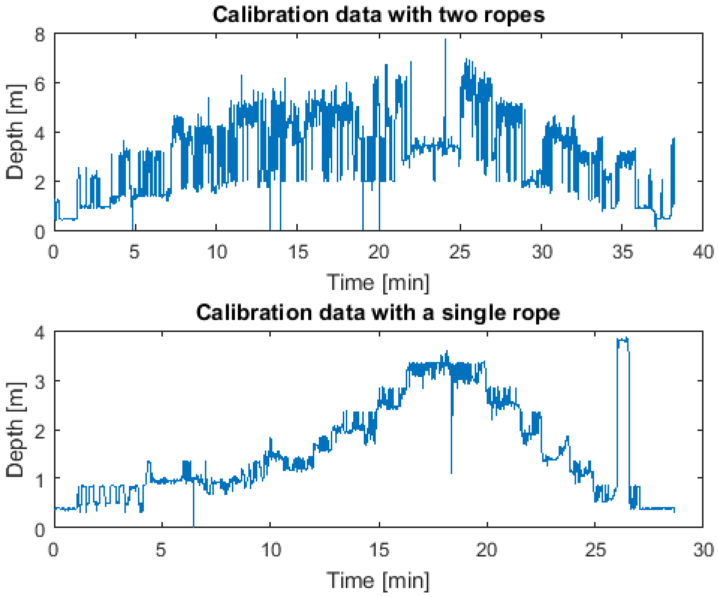


Figure 6. Sample plate check calibration data collected in a ~3.5 m deep swimming pool

5.3 Survey camp exercise – student's perspective on the calibration options

From the perspective of a former student who has performed these field exercises using the original implementation and who has tested and developed potential improvements via the move to a canoe / catamaran style setup a few things have become clear.

First, the implementation of a locking hand-winch was a significant improvement to the original lesson design. The lake where the exercise was conducted is approximately 30 m deep, which required one or more students to focus their primary attention and effort on the adjustment and stabilization of the calibration plate. Not only does this introduce a measure of imprecision into the rigorous calibration procedure, it also detracts from those students' ability to engage with the other aspects of learning which could be imparted during this time. By offloading the most demanding part of the calibration procedure to a mechanical system, the depth of the calibration plate is more consistent, stable, and known with an improved level of precision. Anecdotally, this task was one of the most unpleasant parts of the hydrography exercise, so much so that when the improvements were described to another former student, he lamented that manually lifting and lowering the calibration plate was something of a ”rite of passage” for students in the program to endure. Also, where we initially thought moving to the two-rope setup for calibration would improve the results by reducing measurement noise, our experiments in the pool have shown that not to be the case.

Second, the implementation of the catamaran setup using two canoes offers some advantages to the fishing boat used previously. Since the lake where the exercise is performed does not have a proper boat launch, the hydrography students are tasked with hauling the gear from the parking area down to the waterfront. Using canoes requires a few more pieces of gear, but each piece is individually smaller and more manageable for a student or team of students to carry. Additionally, the canoes allow three students to accompany the instructor during the exercise, where the fishing boat only allowed two students to be included. Ideally, all the students would get a chance to experience the surveying process from within the boat, but this is dependant on time, manpower, and budgetary constraints. As it is, the canoe catamaran offers more students the chance to get hands-on experience within those current constraints, which must be seen as an improvement to the teaching methodology.

6. SUMMARY AND RECOMMENDATIONS FOR FUTURE WORK

This paper described the recent design and developments of two geomatics engineering university courses related to hydrographic surveying. The measurement of graduate attributes in order to satisfy the engineering accreditation board was explained. Also, meeting the list of topics and sub-topics prescribed by the board of examiners for professional surveyors was also discussed. Both these tasks were tackled through the lens of Bloom’s taxonomy, which is a hierarchy of congnitive levels related to the action verbs used in defining learning outcomes. Lastly, recommendations on how to run a hydrographic surveying exercise during a survey camp were given. The exercise is an opportunity for the students to gain invaluable field experience in collecting their own SBES data. The specific problem discussed was how to perform a rigorous plate check calibration for a HyDrone in an accurate and safe manner. The final conclusions were to assemble a two-canoe catamaran to serve as a stable calibration platform where a special contraption is built for keeping the HyDrone in place, and a single rope system with a winch and gear reduction capabilities is used for suspending and raising the calibration plate.

The main author’s intention is to continually improve the two courses discussed in this paper. Future work for the theory course includes adding more in-class TBL exercises, and, keeping the lecture material and the laboratory assignments current. In terms of the field exercise in survey camp, the authors would like to test more types of canoes, and potentially use a different type of rope that is compatible with a commercially available winch and which may not add to the exhibited multipath systematic effects. Testing a different SBES may also be beneficial. Finally, the author would like to poll the students involved in the two courses about their theory and field work learning experiences.

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BIOGRAPHICAL NOTES

Dr. Ivan Detchev received his BScE (First Division) in geomatics engineering from the University of New Brunswick. Both his MSc and PhD degrees were in close range photogrammetry / digital imaging system from the University of Calgary. His MSc thesis was on the 3D reconstruction of scoliotic torsos, and his PhD dissertation was related to image-based fine-scale infrastructure monitoring. He is currently a tenure-track instructor in surveying and mapping in the Department of Geomatics Engineering at the University of Calgary, where his research focus is transitioning towards engineering education / the scholarship of teaching and learning.

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