Universal Design for Learning in a Surveying Course

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SUMMARY

Universal Design for Learning (UDL) is an educational framework meant to accommodate learning differences and to enhance the educational experience of all students. This framework incorporates varied means of engaging students, representing material, and expressing student understanding. Geomatics education lends itself well to the UDL framework, as demonstrated in this paper discussing its implementation in three surveying courses at the University of New Brunswick. These courses involve a large volume of challenging material, including instrument operational principles and errors, and their application in a wide variety of survey types.

Student engagement was improved by several means. Relevance of the material was communicated by incorporation of real-world problems, and relation of the course work to industry practice. Assignments allowing choice in topic better motivated students by freeing them to pursue individual interests.

Course material was represented using some traditional means such as texts, lectures, and practical lab exercises; but also included videos, simulations, demonstrations, and manipulatives. These were often incorporated in a partial flipped classroom approach, such that students were able to learn and experiment with concepts outside of class in several different ways, with class time spent on active learning or interactive discussion of challenging concepts.

Diverse assignments provided multiple means of expression, augmenting traditional written expression with verbal expression through student-led teaching sessions and oral examinations. One assignment fully employing UDL principles allowed students to choose a current topic with multiple options for expression.

The current paper discusses key examples of innovation in each of these components of the UDL framework, showing how the framework can be effectively applied in Geomatics teaching. Some successes, failures, and lessons learned are included as well as effects on student performance and feedback.

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1. INTRODUCTION

Universal Design for Learning (UDL) is a comprehensive framework for educational design developed during the 1990's by the Center for Applied Special Technology in Massachusetts (Rose & Meyer, 2002). UDL supports design of learning experiences that engage three neural networks believed to play a role in the learning process (Rose & Strangman, 2007). The intent is to engage these networks in a variety of ways, such that learning becomes accessible to a greater range of students, while becoming more effective for every student.

The specific neural networks targeted are the affective networks having to do with engagement and motivation; the recognition networks having to do with retention and processing of information; and the strategic network having to do with planning and performing tasks. These are activated by designing a course to provide (CAST, 2018):

1. Multiple means of engaging students,
2. Multiple means of representing course content, and
3. Multiple means of expression in course deliverables.

Often, well-intentioned course design focuses on one or two of these. For example, an instructor might create or link to videos complementing course topics as another means of representation that reaches more students, or they might include a presentation to the class as a course deliverable because this is an important means of expression for engineers and academics. While these efforts do improve the course from a UDL standpoint, awareness of the UDL framework helps to identify more possible areas for course modification to activate all parts of the learning process. Thus, a course that is well-designed in a UDL sense is expected to meet the learning needs of more students while improving overall student understanding of material and performance on learning outcomes.

UDL has been applied at a variety of educational levels, initially and predominantly in primary and secondary education (Rao et al., 2014), but also in a post-secondary context (e.g. Burgstahler, [2013], Roberts et al. [2011]). The framework improves outcomes related to student engagement and sometimes performance in higher education, including in STEM fields (e.g. Schreffler et al. [2019], Langley-Turnbaugh [2013]).

Geomatics as a discipline is well-suited to UDL. Given its dependence on geometry and use of practical tools, varied means of representing material and expressing understanding are natural. Furthermore, the breadth of topics comprising Geomatics and their growing relevance in our digital, position-oriented world provide additional pathways for student engagement.

In this paper, we will substantiate the thesis that UDL can be effectively implemented within Geomatics by providing several examples of incorporation of UDL principles in course design for challenging upper-level surveying courses within the Geomatics Engineering degree offered by the Department of Geodesy and Geomatics Engineering at the University of New Brunswick (UNB). After overviewing these courses, a series of course modifications to better align them with UDL principles will be presented, along with commentary on challenges and successes of the efforts. Finally, the results will be summarized to extract some general principles for applying UDL in Geomatics education.

2. OVERVIEW OF COURSES DISCUSSED

The UNB Geomatics Engineering program is a four-year degree program including a base of introductory courses and several streams of specialized courses. Each stream comprises a series of two or more courses focused on a specific domain of Geomatics knowledge.
The courses discussed here are all part of the "Surveying" stream, which prepares students to plan, execute, analyze, and understand at a high level the technical operations associated with positioning through GNSS, differential leveling, total stations, and some specialized techniques. The courses associated with this stream are listed in Table 1.

Table 1: Courses in the "Surveying" stream at UNB.

Course	Place in Program	Description
GGE 1001	Year 1, Fall	Introductory Geomatics course, focused (roughly 2/3 of course content) on plane surveying.
GGE 2012	Year 2, Winter	Intermediate surveying course, with more advanced coverage of techniques, computations, and instruments than GGE 1001. Introduces new technologies such as laser scanners.
GGE 2013	Year 2, Spring	Practicum associated with GGE 2012, involving a two-week surveying project following final exams.
GGE 3022*	Year 3, Winter	Advanced surveying course including in-depth understanding of instruments and errors, survey planning and analysis, and geodetic surveying.
GGE 3023*	Year 3, Spring	Practicum associated with GGE 3022, requiring students to plan, execute, and analyze a high-precision control survey.
GGE 5022*	Year 4, Fall (elective)	Technical elective covering specialized surveying applications including underground surveying, areas or limited extent, and deformation monitoring.

Those courses marked with asterisks will be discussed in this paper. Given the volume and diversity of content students must learn in these upper-year surveying courses, they are especially challenging for both instructors and learners. As such, they are a forum where the benefits and challenges of applying UDL are most visible.

3. CHANGES IN COURSE DELIVERY

3.1. Multiple means of engagement

3.1.1. Relation of material to real-world situations

Students in technical disciplines are often oriented toward practical applications their learning. Thus, relevance can be demonstrated by relating material to the variety of practical experiences students have or will experience. This has been done in various ways throughout the courses under discussion—for example in the manner of interacting with students during class sessions—but has been most thoroughly implemented in some key modifications to practical exercises.

In one example, the GGE 3023 course traditionally has comprised an exercise in execution and analysis of a control survey. Unmodified, the exercise prescribed a set of surveying operations including instrument testing and calibration, and connection of an outdoor survey to points within a building. Students undertook a pre-analysis during the preceding GGE 3022 course as preparation for the exercise. This guaranteed students a thorough experience undertaking a variety to tasks necessary for precise surveying, but students often struggled with motivation and understanding of the practical relevance of the experience.

The exercise has since been modified and has become a central part of both not only GGE 3023, but GGE 3022 as well. In GGE 3022, students are now presented at the beginning of the term with a set of client specifications for a survey of new control monuments on the UNB campus. One requirement is that these be positioned to stringent tolerances, that can only be met using the advanced techniques and understanding of errors developed throughout the GGE 3022 course. Students must work as teams during the term to develop proposals for the survey of the monuments, formatted similarly to a real-world proposal for survey work, including elements such as a budget and timeline. Furthermore, it is understood that instrument testing and calibration has not been carried out within the last year, and as such work plans must include these activities as well. The proposals ultimately are reviewed by the class and combined into a work plan to be executed in the GGE 3023 course.

Some parts of the GGE 3023 activities remain somewhat contrived, in that e.g. all students must take turns observing and booking during GGE 3023, and astronomic azimuths must be observed during the GGE 3023 course. However, the majority of the work has the form of a real-world experience in survey planning and execution, allowing students to appreciate the relevance of the course material in a practical context. By reframing the problem in this way, students still undergo the same learning experiences, but with greater engagement because the relevance is clear. Activities are driven by what is required to meet project requirements, rather than by what the instructor requires to grant a passing mark.

3.1.2. Allowing choice of assignment topics

Students are motivated not only by practical relevance but also by interest. Thus, student engagement can also be activated by allowing choice in topics for an assignment. While the sometimes stringent and voluminous content required in surveying can be restrictive, it also creates an opportunity. Whenever a topic may be divided into a series of manageable sub-topics of comparable difficulty level, there is an opportunity for an assignment allowing student choice.

One example of this is found in the GGE 5022 course. By the time students reach GGE 5022, they have had some experience interpreting specifications and relating them to practical surveying requirements. Part of the required course content is to extend the principles of control surveying and error propagation covered in GGE 3022, showing application in various control survey types. For some of these, such as underground surveys or surveys in areas of limited extent, specialized new techniques must be introduced and the difficulty level is too high. Most control survey types however, such as control surveys for construction or photogrammetry, can be understood by application of knowledge and research skills developed in previous courses.

A flipped classroom approach has been effective to exploit this opportunity. In this exercise, students divide themselves into groups based on their interest in a particular survey type. This is facilitated by a Google Sheet with fixed numbers of slots allocated to each type. Students then research their assigned survey type outside of class, identifying relevant specifications and techniques, and ultimately deliver a classroom session on how to perform control surveys of the chosen variety. Class sessions are vetted by the instructor in advance to ensure they are not misleading and provide adequate information. Quality of each group's teaching and learning of the material are ultimately assigned based both on the instructor's assessment of the session the deliver, and also on how well other students score on a quiz given after each session. Thus, the assessment is driven partly by how effective the session has been in terms of student learning, motivating development of effective teaching skills.

This approach improves motivation because students can specifically choose survey types of personal interest to them. Often, they have had summer work experience with the type they choose, which they then bring into the classroom in a very effective way. Furthermore, in its effort to provide students a variety of options, this format has led to inclusion of a greater variety of survey types in the course. Only control surveys for photogrammetry and construction we discussed before the exercise was first implemented, but now students learn about control surveys associated with:

1. Photogrammetry,
2. Construction of buildings or of roads,
3. Terrestrial (Mobile and Stationary) and Airborne LiDAR,
4. Cadastral surveying, and
5. Establishment of GNSS base stations.

Student feedback is an effective indicator of student motivation. Solicited feedback after the first implementation of this method, with mostly positive results. Students universally indicated that they learned a great deal more about their own chosen densification type than they would have otherwise, and often appreciated the research skills they gained. Some negative comments were that attendance was sometimes low because students would skip class when their group was not teaching, and that they would have trusted an instructor more than other students.

From an instructor standpoint, the quality of teaching in the student-led sessions in the first run of the assignment was quite variable, and while students were generally attempting to convey correct information, they were not always conveying it well. In later iterations, requirements were better defined. The assessment based on other students completing a quiz was first implemented last year, and while it did result in more focus on instructional quality, there was sometimes a tendency to "teach to the test." The test questions were such that "teaching to the test" would provide learners with the key information they needed to know, but sometimes at the expense of a more thorough presentation of the considerations surrounding planning an execution of a particular survey type.

Lessons learning the planning and development of this activity include that expectations must be clearly specified, vetting of presentations is important both to ensure quality and to ensure that other students will trust the presenters, and that providing support and recommendations about effective teaching during the vetting stage is beneficial.

3.2. Multiple means of representation

3.2.1. Representation of material in a variety of formats

Providing material redundantly in a variety of formats is the most obvious implementation of multiple means of representing knowledge. This is made significantly easier with an online learning management system is used, and when implementation is done in an incremental way. Indeed, development of new learning materials usually must be incremental, given the high workload university faculty members tend to maintain.

Traditional course formats already provide several means of representation, including slides providing visual expression of concepts accompanied by auditory expression through lectures, often supplemented by textual expression through lecture notes for reading, augmented by hands-on practical exercises. This is beneficial from a UDL perspective, because each student will learn better from a different form of instruction, and because all students will benefit from seeing topics explained in different ways.

Moving further toward a UDL approach on one hand involves ensuring that resources already in use are as accessible as possible. This can be done, for example, by sharing them regularly using a learning management system; by applying optical character recognition software to make readings searchable and readable by text-to-speech software; or by adding image descriptions and explanatory notes to PowerPoint slides. Once an instructor is aware of these possibilities, they can all be implemented with minimal time commitment and little development of new skillsets on the part of the instructor.

On the other hand, a more thorough implementation of UDL moves beyond traditional formats to provide additional resources representing knowledge by a greater variety of means. This could include things like videos, interactive simulations, or work with manipulative objects. Outside video and other resources, vetted and contextualized by the instructor, can sometimes provide more means of representation. Unfortunately, their use for specialized advanced topics may be limited to supporting students who are weak on pre-requisite knowledge or to explaining general ideas surrounding specialized topics.

In GGE 3022, a variety of means of representation are applied throughout, but especially for the challenging topic of gyrotheodolite azimuth measurement. This technique is based on the often-counterintuitive motion of gyroscopes, and instruments used are often “black boxes” whose operation is not easy to relate to the gyroscopic principles behind it.

Before any improvement, the gyroscope topic was already taught using annotated lecture slides, readings, and a practical exercise. These were augmented with the addition of:

1. Demonstrations using physical objects,
2. A computer simulation relating gyroscope movement to use, and
3. Videos explaining gyroscope operation and use, and some relevant calculations.

A demonstration gyroscope, shown in Figure 1, has been a valuable tool in showing in a more concrete way the nature of gyroscopic motion. This model is the Super Precision Gyroscope from Gyroscope.com. It can rotate freely on gimbals, but can also be removed from its base such that it is constrained to rotate around one axis, like the gyroscope in a gyrotheodolite. The demonstration gyroscope allows the connections to be illustrated between behaviour of a free gyroscope, behaviour of a constrained gyroscope, and behavior of a constrained gyroscope under the influence of an external torque such as Earth rotation.

Figure 1. Demonstration gyroscope.

A second-hand GAK1 gyroscope has also been used, with its outer casing removed, to demonstrate how a constrained gyroscope is then integrated into a surveying instrument that can be affixed to a theodolite for determination of the North direction. This is an especially salient example, as it is the same model of gyroscope that students use for a course laboratory exercise shortly after gyroscope concepts are introduced. The instrument, with cover removed to show the interior workings, is shown in Figure 2.

Figure 2. GAK1 gyroscope with casing removed.

The computer simulation was created using Microsoft Excel. It is designed so that a user can choose how far a gyroscope is pointing form North, and its range of oscillation, then induce the gyro to start moving and follow its behavior. The gyroscope movement is shown both as a mathematical plot matching the style of plots in course readings and slides, an illustration of how the gyroscope disc is rotating, and an illustration of what would be seen through he eyepiece of the GAK1 gyroscope as the disc rotates. An screenshot of the simulation output and user controls is shown in Figure 3, with sliders for center of rotation, amplitude of oscillations, and up and down arrows which can be pressed to see the movement of the gyroscope disc (rightmost plot), the mathematical plot of gyroscope position (middle plot), and the GAK1 beam display (leftmost plot) as the gyroscope rotates.

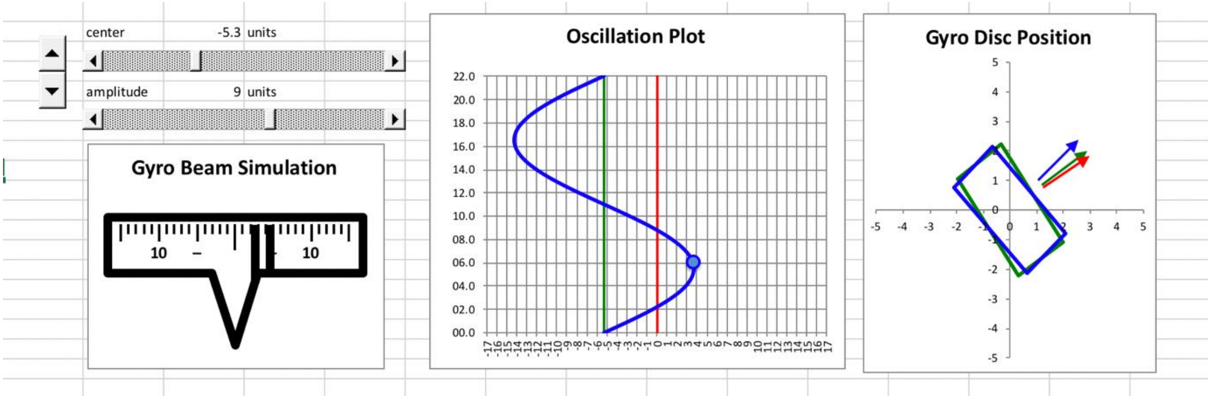

Figure 3. Output and user controls of Excel gyroscope simulation.

Videos of two types are associated with this model. A graduate student was hired using UNB’s Teaching and Learning Priority Fund to create a series of videos explaining gyroscope principles using animations, images, and voice, and then linking these to their applications for surveying, and ultimately to an explanation of how to use the GAK1 gyro instrument. Also, videos of azimuth computations have been produced using a LiveScribe pen to walk students through the calculations associated with transforming the azimuth computed from the gyroscope readings into an azimuth in other coordinate systems.

It is difficult to isolate student performance on gyrotheodolite deliverables alone, but students do complete a gyroscope practical exercise that has not been modified substantially in terms of evaluation since before the supplemental materials described here were created. The average assignment mark has increase from 71% to 80% over the time these materials were being implemented, but perhaps more importantly the proportion of students receiving marks of A or higher has increased from 43% to 63%, while those with C or lower has dropped from 16% to 7%. This suggests that the UDL goal of reaching more learners is being achieved. Videos of worked through calculations have been an especially valuable addition, not just for the gyroscope topic but for the GGE 3022 course in general. Instead of demonstrating calculations on the board in class and hoping that students note and retain everything relevant the videos allow students to review calculations after the class, including when they are actually applying them. Explanations accompanying the calculations in the video are then better appreciated, and students learn more effectively the nuances of where formulas come from and how they should be applied. Indicative of this, the average student mark on the calculation portion of the final exam averaged 44% in the 2 years before calculation videos were provided, but averaged 61% over the 2 years after videos were provided. The benefit is well stated in the anonymous feedback of one undergraduate student: "Sometimes with the slides and class discussions, you learn something, but then you forget it, like you can forget what the terms in the equations mean. With this you can review it and remember that."

3.2.2. Moving toward a flipped-classroom model

In a traditional model, learning takes place primarily in the classroom through means of representation such as lectures or demonstrations. This learning is then possibly supplemented by learning outside the classroom through readings, and opportunities to interact with course material are provided through assignments and other activities outside of the classroom. A flipped classroom model, by contrast, has individual learning happening outside the classroom, though review of lecture notes, videos, or other means of representation. Classroom sessions are then used for expression of understanding and working through of what is learned, with the help of the course instructor.

A partial flipped classroom approach has been applied throughout the GGE 3022 course. As already discussed, a variety of materials are provided to students to help the learn course content. The organization of materials is structured around a set of thoroughly annotated slide decks, which students are expected to review out of class. Other resources such as videos, simulations, example calculations, and readings are provided, associated with different sections of the slide decks to which they are relevant. Class sessions then take the form of:

1. Revision of some key difficult topics from the slide decks,
2. Hands on activities or demonstrations reinforcing course material,
3. Focused sessions dealing with specific areas of weakness in student learning identified during the term,
4. Opportunities for student-driven discussion of material from slides, readings, etc., or
5. Active learning exercises applying material covered in course resources.

While items 1-3 above fit well within the UDL paradigm, they would not be considered flipped classroom activities. However, use of classes for these purposes has been especially valuable, and this course will therefore likely never use a fully flipped classroom approach. Items 4 and 5 on the other hand fit well within the flipped classroom approach.

There is often concern with flipped classroom that is students can learn everything they need without coming to class then attendance will drop substantially. That has not been the case here. Owing to the difficulty of the course material and its perceived practical relevance, most students attend most classes, except in cases of illness, poor weather, or high workload from other courses. In these cases, the flipped classroom approach is especially effective, because absent students do not fall behind on course content, demonstrating the UDL principle that an approach meant to reach more learners makes things better for all learners.

A challenge with the flipped classroom model has been to have students buy in to the effort. They are being asked to take far more responsibility for their learning than in most other courses, and while this is overall a good thing, it should be recognized that this may be a new experience and one that they will only commit to if they see value in it and know how to do it. Even for students have experienced flipped classroom courses before, these often focus almost exclusively on video content, rather than a diversity of options. It is then disappointing to them that the GGE 3022 video archive is not yet fully developed, so they must still learn from formats they are less comfortable with. In general, students have reported that they learn best from video content, with comments such as: "Build the video archive, great way to learn," and " I didn't understand the parallax and refraction corrections until I saw you go through it in the video." As the quantity of review materials grows, and as they become more accessible and become available in formats suited to a greater variety of learners, and as more ways are found to guide independent learning, this challenge is expected to diminish. Growth in video content is expected to have the greatest effect.

Incorporation of active learning exercises has been one of the most important tools for successful flipped classroom implementation. Class active learning exercises allow students to work through and improve their understanding of course material with an instructor's assistance. This helps to identify and then to address gaps in the understanding of the class as a whole, but also supports differentiated learning as difficulties of individual students can be better addressed by the instructor or by their group members as they work through questions, scenarios, or problems. Geomatics is well-suited to active learning because of the abundance of practical situations that can be used as bases for problem solving in active learning activities. This is doubly true in a design-oriented course like GGE 3022, because diverse, interesting, and relevant practical design problems are not difficult to find.

A more complete implementation of the flipped classroom concept is contained in the exercise form GGE 5022 that was discussed in Section 3.1.2, which required students to undertake independent research outside of class and to present the results to their peers. This seminar style approach is a very traditional within academia, but also fits extremely well in the modern educational paradigms of UDL and flipped classrooms.

3.3. Multiple means of action and expression

3.3.1. Evaluation of expression through multiple means

Multiple means of action and expression can be implemented at many levels beyond the diversity in deliverable format that is discussed here (see, for example, Principle 3 in the current guidelines by CAST [2018]). However, we will focus in this paper on using diverse deliverable formats for expression of understanding, because that has been the dominant implementation in the courses being discussed. Diversity in deliverables can be implemented by requiring different formats for different deliverables, as discussed in this subsection; or by allowing the deliverable for an assignment to be in one of a variety of possibilities, as discussed in the next subsection.

Diversity of deliverables is already implemented to an extent in many Geomatics programs. Students are often required to make presentations to demonstrate understanding of material, or to report on practical tasks representative of their ability to apply what they have learned in field or computational operations. However, requiring deliverables in an even greater variety of formats will allow students who struggle with typical formats to more effectively express their understanding of course material, and to have their understanding assessed more accurately, while also requiring all students to become conversant in diverse methods of expression. Expansion of the means of expression available to students may involve reintroducing traditional means of expression such as oral examination, or it may mean requiring new means of expression such as blogs or video.

A number of changes have been made to all three courses discussed to include more diverse means of representation for assessment. One of the most effective has been implementation of oral examinations as part of the summative assessment in GGE 3022 and GGE 5022. Oral examination—a very traditional tool that is now rarely practiced in undergraduate education in North America—requires oral expression of understanding in an interactive and interpersonal way that is distinct from written reports, examinations, or structured and rehearsed presentations. The argument for this on the basis of relevance to professional practice is easy to make to students: It is very common that a professional must explain a complex topic orally, on the spot, to a co-worker or client. Furthermore, other tools such as written examinations are limited in their ability to assess depth of understanding of a topic, because for example a student may simply misunderstand a long answer question, or may not appreciate exactly which detail is called for. The ability of oral examination to probe the depths of a student's understanding is why they remain common in examinations for graduate degrees. Undergraduate students may also, under the contrived pressure of an examination room, fail on a technical level to adequately express their understanding of a topic, even if they could express it capable in an industry setting where they are discussing it with a colleague. In oral examinations the examiner can clarify questions if the student misunderstands them, can prompt for more information if needed, can ask students to clarify anything they have miscommunicated, and can help the student to overcome anxiety if it is becoming a barrier to effective assessment.

While oral examinations are a challenge for some students, in particular due to discomfort with oral communication, this can be mediated by a compassionate approach on the part of the examiner. As long as it does not crush the student, and oral examination can ultimately help them to identify and address issues surrounding interpersonal communication, and improve on them for the next time. At the same time, some students who are uncomfortable in traditional examinations report a strong preference for oral examinations. Because a Geomatics Engineering degree is required to become a land surveyor in Canada, the program sometimes attracts students who may not fit well in traditional academic settings, but who have the strong skills in interpersonal communication that are quite valuable for things like working with a field crew or interaction with property owners. These skills are rarely recognized directly in any academic way, but they are beneficial in an oral examination. Furthermore, in GGE 3022 and GGE 5022, oral examinations are accompanied with a whiteboard for illustration so that students who most effectively express their understanding graphically are also supported.

By including oral examinations as part of their summative assessment, a student's assessment provides a better indication both of depth of student understanding, and of their ability to express that understanding in a way essential to the Geomatics profession.

3.3.2. Allowing student choice in deliverable format

The best implementation of multiple means of expression detaches ways of expressing knowledge from the knowledge itself. The idea is that rather than prescribing a means of expression, the student is allowed to choose how they will show their understanding, whether in a way that better challenges them or alternatively one that they are more comfortable with. This gives students ownership of another aspect of their learning, and thus has a secondary benefit of improving student engagement.

This kind of implementation becomes challenging when both means of expression and knowledge expressed are to be assessed. Work and careful thought are required to pair such an implementation with other good pedagogical principles, such as providing students with clear guidance about expected outcomes and clear assessment rubrics, because either a very broad rubric must be created that can cover all deliverable types, or more specific rubrics must be made for each deliverable. It useful to have some assessment of quality of the deliverable if students are to benefit from attempting new formats, to provide feedback on their attempts while also ensuring that quality of deliverables is not allowed to suffer.

Thus far, student choice of means of expression is only fully implemented in one “Lifelong Learning Assignment” in GGE 5022. The title of the assignment refers to the “Lifelong Learning” Graduate Attribute prescribed under the Washington Accord (IEC, 2014), which indicates that graduates should have skills in independently researching and learning about new ideas. It is suitable for an assignment built around this attribute to provide an opportunity to learn about new deliverable formats as well.

In this assignment, students identify a tool, technique, or case study of their choosing associated with the course topic of Precision Surveying. This is another instance of motivation by allowing choice of topic. A Google Sheet is used so students can fill in their topic as soon as they choose it, and can sign up for time slots for deliverable formats that require them, preventing multiple students choosing the same topic and simultaneously scheduling all presentations or demonstrations to the class. The student then investigates the topic and any necessarily background knowledge, such they that would be able to explain their topic to others. Finally, they choose a format of deliverable to present their understanding of the topic to the class. Suggested formats are:

1. A short (5-7 page) paper,
2. An oral presentation (~7-10 minutes in length),
3. A short practical demonstration,
4. A poster or graphic, or
5. A video (~7-10 minutes in length).

Guidance on expectations is given for each of these options, along with a brief indication of where each format could be useful in an industrial setting. Students are optionally allowed to choose a different format than any of these, with permission of the instructor.

While most students stick with means of expression that they are more comfortable with—often not willing to sacrifice time or marks to learn new tools or ways to express their thoughts—several each year take up the challenge to try to something new. There have been excellent submissions in all formats, but students tend to prefer the short paper format, which does not require standing in front of the class and can be put off until the final due date. A significant number of students have experimented with the poster/graphic format, indicating that they are willing to try new things. Only one has thus far attempted the video format, but he has done an excellent job that will be used as an example to encourage students to try this format in the future. The distribution of formats used each year since the inception of the assignment in 2017 are shown in Table 2.

Year	Short Paper	Presentation	Demonstration	Poster/Graphic	Video
2017	11	6	0	5	0
2018	20	8	0	9	0
2019	15	5	0	3	1

Table 2: Distribution of deliverables for GGE 5022 Lifelong Learning Project.

4. CONCLUSIONS

It is evident from the numerous examples above that, at least in the case of a surveying course, opportunities to implement UDL within a Geomatics program abound. Geomatics, with its dependence on geometry and spatial information, lends itself to graphical illustration rather than lectures alone. The practical nature of the discipline lends itself to incorporation of practical, hands-on exercises and connections with real-world problems. Furthermore, Geomatics programs already apply some UDL principles, which can be expanded upon to reach more complete UDL implementation.

In some cases, applying UDL principles means reviving traditional teaching methods such as seminars or oral examinations. In others, new technologies and teaching methods can be helpful. For example, presentation of material in newer formats such as video and computer simulations; use of tools like Google Sheets and learning management systems to make material more accessible and organization more clear; and use of new teaching models such as flipped classrooms; address some of the UDL principles in more effective ways than a traditional approach would allow. Some of these modern techniques and tools are used effectively by instructors who have never heard of UDL, but what UDL adds is a comprehensive framework to understand the teaching process from a universal design perspective, such than an instructor aware of the UDL framework will have fewer blinds spots about the different aspects of universal design that may affect student learning in their courses.

In many cases, addressing one UDL principle will correspond to also addressing another. For example, the Lifelong Learning Assignment in GGE 5022 allows multiple means of representing knowledge, but also applies multiple means of motivation by allowing students to choose topics of interest and to have control over how the deliverable is expressed. This underscores the integrated nature of choice design, including in the application of UDL principles. Often a modification meant to address one principle will have benefits for others also.

Communication is important for effective UDL implementation. Especially when new or unfamiliar teaching practices are applied, it is necessary to have buy-in from students, which requires communication of the expected value of the new way of doing things. Rubrics should be applied to clearly explain how new means of expression will be evaluated, and guidance is needed on how the different means of representing knowledge are related to one another. Furthermore, because a major goal of UDL is to make education accessible to all learners, it is necessary during implementation of course modifications to regularly seek feedback from students. This may be done informally in casual conversations, by observation of student performance, or formally using some feedback mechanism. The key is to ensure that UDL goals are being realized.

Finally, it is necessary to recognize the constraints that we as instructors are under, and not to over extend. While the ideal is design of course from the ground up with UDL in mind, in practice university educators have usually taken over or been assigned to create a course that has a certain role within a larger program. This means that our options may be quite limited in terms of course content and learning outcomes such that we cannot completely redesign the course. Also, given typical faculty workloads, we rarely have time for a complete redesign. The good news is that improvements can still be made. The changes discussed in this paper gradually move the courses toward addressing more and more UDL principles, and just a few new ones are implemented each time the course was run. The benefits begin to be realized right away, and this can be motivating. So, even if it is not most ideal, there is great value in incorporating UDL principles in your course, that can be realizing incrementally starting immediately.

A benefit of incremental adoption of UDL principles is that you are not pressured to understand everything about UDL and its implementation all at once. You can start applying principles, see the flaws, get better at it, and ultimately make UDL a natural part of your thinking about the experience of your learners. In the discussion of some of the methods, we see from student feedback that there are flaws that have been addressed, and that are still to be addressed, ultimately moving toward a UDL implementation that is affective for all learners.

Finally, it is important to be bold. If exposure to the UDL framework has prompted an idea that you think will be feasible to implement, add it to the syllabus and commit. Make the best first effort that time allows, but then open yourself to feedback and begin the learning process of how to do UDL better. To the extent that you get it right, students will become more engaged and better learners. This is what every instructor wants, and is the reward that UDL offers.

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BIOGRAPHICAL NOTES

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