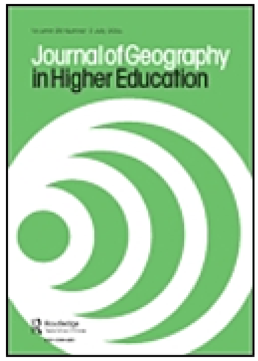


# Authentic learning using mobile applications and contemporary geospatial information requirements related to Environmental Science



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## Abstract

In this paper, we examine the potential of authentic learning activities and assessment to enhance the student learning experience in a standalone introductory geospatial information science module. Computer laboratory sessions form seventy-five percent of contact hours and final grade, so authentic learning used a field-based project with specified features, study area and aerial photo form the basis of assessment. The class collects all relevant geospatial information using mobile devices. Students present personally collected, and class-merged geospatial information as workplace style reports in scaffolded assessments. All submitted data are collected by the class and managed by the students. Essential skills and employment opportunities using GIS skills form the basis of authenticity of this module and guide student expectations. We evaluate outcomes through a two-year case study examining design, implementation and revision of the Unit, by using a mixed-methods approach including multiple, staged student surveys, focus groups, student results, peer observation, and the Lecturer's reflective journal. A focus on authenticity increased student appreciation of employability in GIS-related positions, and students reported increased motivation to learn.

Keywords: authentic learning design; authentic assessment; geospatial app; employability

Subject classification codes: include these here if the journal requires them

## Introduction

Geography and geospatial information sciences are fundamental components of Environmental Science (Gharehbaghi and Scott-Young, 2018). The standalone Unit presented here consists of fifty-two formal contact hours over thirteen weeks and focuses on developing authentic and transferable skills aligned to predominant graduate employment options. Environmental site investigation, interpretation, reporting and analysis are essential for compliance with State and Federal environmental legislation in Australia ( https://www.legislation.qld.gov.au/view/pdf/inforce/current/act-1994-062). Specifically, students demonstrate competence in field data collection; file formatting and reprojection; tabulation of location-based data sets; data quality control and database management; transfer of data between GIS platforms; construction of basic cartographic products and geostatistical and spatial analytical processing inform and justify decision making. The University's stated goal is to develop graduates who will be "curious, agile and resilient learners", "effective collaborators and communicators in disciplinary and interdisciplinary contexts", and "employ digital literacies and use technology strategically to leverage information and to collaborate" (QUT, 2020). These outcomes are to be achieved by a range of learning approaches and strategies, including the provision of "authentic learning and assessment", and related Work Integrated Learning (WIL), and "be enhanced through online and blended learning technologies and tools" (QUT, 2020). These are part of a broader suite of strategies, but they are the most relevant for our purposes here.

In this paper, a second-year geospatial information science Unit is evaluated with a specific focus on authentic learning design (Huang, 2011) and integrated assessment (Birenbaum et al., 2006), and by extension on employability. In particular, the Unit design focused on student collected geospatial information. The module is the only compulsory geospatial information science content for Environmental Science Major students. In Australia, environmental scientists often collect both samples and geospatial information in the field to meet statutory obligations for development and other potentially environmentally harmful activities. This workplace reality informed Unit design and assessment construction.

Overall, the Unit design sought to create an authentic learning experience based on an archetypal field-based project. Firstly, mobile mapping applications allow students to collect geospatially located field data containing specified attributes. The application for personal devices was provided free of charge. Institutional mobile devices were provided for those without suitable devices or those who were concerned about using a personal device (Welsh et al., 2018). The field location adjoins the campus, and data collection was conducted during timetabled contact sessions to encourage student participation (Peacock et al., 2018). Secondly, all subsequent laboratory activities and summative assessments used students' personally collected data or merged class datasets that students had personally cleaned. The assessment activities aligned with submitted elements of standard environmental compliance and impact reporting (https://apps.des.qld.gov.au/env-authorities/). Thirdly, the summative assessment items were scaffolded for students to demonstrate both technical competency and understanding of the concepts listed below. Three assessment items covered the following geospatial information concepts: (a) uncertainty in location, thematic and quantitative field-collected data; (b) search effort, sampling bias and database accuracy; and (c) spatial autocorrelation, geostatistical assumptions and decision support.

Briefly, this required: (a) field data collection on mobile devices, download and file conversion, (b) data cleaning, merging and quality control including spatial accuracy, feature duplication and data entry errors, (c) preparation of cartographic products for specified clients, (d) a report proposing spatially explicit and quantified improvements to amenities in the study area.

Lectures were ordered and structured to address theoretical content applied in the laboratory activities and development of analytical thought regarding geospatial information. Lecture topics included Global Navigation Satellite Systems, geospatial data geometry and file formats, geographic and projected coordinate systems, geospatial patterns and processes, remote sensing theory, geospatial statistics and basic cartography. Weekly activities examining spatial patterns and underlying processes developed geospatial information interpretation skills. The fundamental component of the success of this approach was student-created geospatial data at the individual student level. The collected data were collectively used by the class to create contemporary geospatial products and analyses commonly requested by employers.

The process of implementing a new learning design and delivery is taken as a case study and evaluated using a mostly qualitatively-focused version of a mixed-methods approach including student surveys at different points during the semester, the Lecturer's reflective account, expert peer review of teaching in the Unit, and two focus groups with students towards the end of each semester in both iterations of the Unit. In other words, while some quantitative data are used, for example in the form of student results, percentage of assessment submissions, and student evaluation data, the emphasis is mostly, and deliberately, on qualitative data as part of an in-depth case study, or what Mason (2006, p. 9) has called "mixing methods in a qualitatively driven way" (see also Creswell, Shope, Plano Clark & Green, 2006). The concept of authentic learning and how it relates specifically to geospatial information science is explored first and then applied to the specific case study. Stake (2005) argues that the point of case studies is to optimise understanding of a single case through an in-depth focus, rather than to generalise beyond it. The results presented in this paper suggest that the approach taken has significant benefits in relation to developing both students' awareness and their expectations around employability, as well as their employability skills.

***Authentic learning and assessment***

Employer and industry demand partly drive an increasing emphasis on authentic learning and authentic assessment in the higher education sector in general, whereby an often-heard complaint is that graduates lack work-readiness upon graduation (Daniels & Brooker, 2014; Jollands, Jolly & Molyneux, 2012). Addressing this lack of work-readiness is a particular focus in the Institution where the case study in this paper is situated. As part of accreditation cycles, course advisory groups, consisting of industry partners, provide feedback about work-readiness (or otherwise) of graduates. There is thus a push towards relevant pedagogical approaches such as Work Integrated Learning (WIL) (Ferns, Cambell & Zegwaard, 2014; Jackson, 2015), and Problem-based Learning (Prosser & Sze, 2014; Walker et al., 2015). In some cases, these approaches include a requirement for students to gather and manipulate live data, as in this paper's case study. As Schonell and Macklin (2018) note, "industry demands highly-skilled, work-ready and adaptable graduates who can solve complex problems" (p. 1197). Geography is naturally suited to authentic learning, yet GIS practical work often reverts to cookbook approaches where students learn how to use a tool in a prescribed manner without any depth of understanding (Bearman et. al., 2016). This paper outlines the selection and design of pedagogies that are as authentic as possible, dynamic, and that require students to adapt and solve complex problems.

Authentic learning can be defined as "learning that is seamlessly integrated or implanted into meaningful, 'real-life' situations" (Howland et al., 2012, p. 5). Similarly, Herrington, Parker and Boase-Jelinek (2014) define it as a learning pedagogy that "not only allows students to engage in realistic tasks using real-world resources and tools, but it also provides opportunities for students to learn with intention by thinking and acting like professionals as they address real problems" (p. 23). Bhagat and Huang (2018) summarise it as "an instructional approach which allows learners to discuss, explore and collaborate to construct new knowledge and create new real artefacts in real-world settings and tasks" (p. 5). Finally, Özür (2019) defines it as a "learning strategy that uses real-life problems, situations or environments in which students are made active" (p. 29). Ultimately, this approach is not new and has been theorised for a long time (e.g. Dewey, 1987). However, its application has gained increasing urgency in recent years in the context of changing job markets and required skill sets (Kek & Huijser, 2017). In relation to applications of authentic learning, and in particular the design of authentic learning, Herrington, Parker & Boase-Jelinek (2014) suggest nine elements:

1. Provide an authentic context that reflects the way the knowledge will be used in real life
2. Provide authentic tasks and activities
3. Provide access to expert performances
4. Provide multiple roles and perspectives
5. Support collaborative construction of knowledge
6. Promote reflection to enable abstractions to be formed
7. Promote articulation to enable tacit knowledge to be made explicit
8. Provide coaching and scaffolding
9. Provide for authentic assessment of learning. (p. 25)

In the context of geospatial information science and this study, authentic learning is applied as a pedagogical framework that is aimed at ensuring students can demonstrate the skills and thinking required to deliver value across the dominant fields and industries that employ environmental scientists. The nine design principles outlined above serve as a reflection tool to analyse the design of the Unit under discussion.

So far, authentic learning has been discussed from a learning design perspective in response to demands from employers and the broader skills market. However, there is another potential perspective that can drive a focus on authentic learning, which is the student perspective, and it is based on characteristics of particular student cohorts and their motivation for learning. At the case study institution, there is a large cohort of school leavers that can be classed as 'millennials' (anyone born between 1981 and 1996) or Generation Z (born 1997 onwards) (Dimock, 2019). A recent survey suggests that millennial generation workers now view tertiary education as no more important than on-the-job, continuous professional development and employer-funded training courses (Deloitte, 2018, p. 25). McHaney (2012) has noted that millennial students are purposeful people who seek relevant skills and knowledge that are taught efficiently while giving them a meaningful experience. This suggests that these students have an expectation that they will have access to authentic learning environments, which is not the same as suggesting that they are necessarily prepared for such environments, as the data in the case study will show. In this sense, some myths and assumptions about the millennial generation, in particular as they relate to their use of technology, have been comprehensively debunked. For example, as Lai and Hong (2015) have shown, "generation is not a determining factor in students' use of digital technologies for learning nor has generation had a radical impact on learning characteristic of higher education students" (p. 725). Overall then, the case study in this paper is used to evaluate a particular instance of authentic learning design in the form of a range of responses from different stakeholders. The research question addressed in the case study is: How can authentic learning and assessment design be applied to develop both students' expectations around employability and their employability itself in a geospatial information science Unit?

**Methodology and methods**

For this study, a mixed-methods approach was employed in relation to a specific case study, "mixing methods in a qualitatively driven way" (Mason, 2006, p. 9), as explained earlier. Mainly qualitative data (with some quantitative data) were collected and analysed to evaluate a redesign of a specific a second-year geospatial information unit, and its employment of mobile location data collection applications to create an authentic learning experience for students in the Unit. Application of mobile mapping applications in tertiary GIS study are well established (Carlson 2007, Price et al. 2014). More recent research shows that most students are happy to use their own mobile devices for learning (Welsh 2018). Historical instances of this Unit used a limited pool (<10) of institutional devices such as the Garmin eTrex. This effectively limited each student to collecting several features during class. This approach was inadequate for the goals of the redesigned Unit because students were unable to demonstrate their ability to collect field data, while repeated measurement of feature location was impractical and it was impossible to collect sufficient data to allow student database management and cleaning. In this study, the local Botanic Gardens site presented a negligible risk of damage to personal devices while a standalone data collection app that students could install and remove as desired limited the sense of invasion reported by Welsh et. al. (2018). The applications used addressed teaching and ethical requirements for data management while also removing cost and software registration issues for students. Teddlie and Tashakkori (2009) have noted that “mixed methodologists present an alternative to the QUAN and QUAL traditions by advocating the use of whatever methodological tools are required to answer the research questions under study” (p. 7). In the case of this study, a mixed-method was considered beneficial in that the use of each method had the potential to reinforce the other, but the main emphasis was on qualitative methods, as the key objective was to gain an in-depth understanding of the impact the learning design on student learning and the student experience in the case study. The use of quantitative data (e.g. grade statistics, student survey data) was seen to add some depth to the mostly qualitative findings (e.g. focus group, expert peer observation, teacher’s reflective journal). The research questions in this case asked whether the design of the Unit worked, or in other words, whether it led to a quality and authentic learning experience for the students involved, and a mixed methods approach allowed us to analyse both student learning outcomes and student experiences in this particular Unit.

This mixed methods approach was part of an overall case study format (Yin, 2011). According to Freebody (2003, p. 81), the goal of a case study, in its most general form, is to develop a study in which both researchers and educators can reflect upon particular instances of educational practice, i.e. the redesign of a particular Unit. Similarly, Stake (1995) defines the case study as “the study of the particularity and complexity of a single case” (p. xi). This is highly relevant to the objectives of this study as one of the researchers was the teacher in the Unit, while another was heavily involved in the design of the Unit, so a case study would allow them to reflect on both the design and its application. As noted, the specific methods used in this case study included student surveys, student results, teacher reflections, expert peer reviewer reflection, student focus group data, and selected student-teacher personal communication. The data thus gathered have been anonymised in compliance with the University’s ethics approval (institutional ethics approval number: 1800000522).

***Case Study Overview and Context***

While many areas of Environmental Science implicitly apply geospatial information, the Unit under discussion is currently the only compulsory geospatial information science subject and only GIS Unit offered across the Faculty. Limited time and resources are a common problem for geospatial science (Bearman et. al., 2016). The Unit is one module of 24 required to attain a Bachelor of Science. Students are not required to have undertaken secondary school science subjects before enrolling in the Bachelor of Science at this University. For most students, this

Unit represents the first and only time they actively learn about geospatial information science and geospatial thinking before entering the workforce. It is not a prerequisite for any higher level Units, so enrolments included students starting second year (3rd semester) to final semester (6th semester) of undergraduate study. Enrolments were sixty-six and eighty-five in 2018 and 2019. Assessment items follow a generic Environmental Science project framework, which commences with the collection of field data for target features (location, attributes); data quality control and preparation following transfer to GIS; visualisation and analysis; and finally decision support (Figure 1). This workflow formed the basis of four assessment items submitted by the students:

1. A short report presenting personally collected geospatial data and data handling, including format conversion and transfer between GIS platforms as well as tabulation of attributes (Assessment 1).
2. Data cleaning and quality control, including selected data repair or editing with edit tracking. Comparison of personal data with class data and development of basic cartographic products based on simple geoprocessing tools (Assessment 2).
3. Preparation of a cartographic product for a pre-specified client. Students were required to use their own and class merged data to create a map displaying features of interest to a particular end-user (Assessment 3).
4. Proposal for works to improve amenities with a justification based on spatial analyses, including geostatistical interpolation, proximity and coverage (Assessment 4).

Briefly, students collected field data (>70 features each) and uploaded the collected data to a class folder. The Lecturer merged the uploaded files to a single feature layer and provided this to the class. Students created attribute fields to identify records as repaired or excluded and set SQL definition queries to track their edits. In this way, each student developed a unique, cleaned and checked version of the class data and a record of database editing. Repairs or removal included spelling or out of range data editing, poor location accuracy, missing data fields or duplication. This aligns with points two, four and five of Herrington, Parker & Boase-Jelinek (2014) as graduates must collect new geospatial information in the field and contribute this data to team projects and reports. Finally, students used their class data set to propose and quantitatively justify improvements to amenities within the gardens against specific parameters. The coordinator provided only the City Botanical Gardens boundary, a current high-resolution air photo and target feature classes for collection.

{FIGURE 1 NEAR HERE}

Tertiary education in environmental science develops human resources to meet legislative requirements for managing activities that cause environmental harm. As a result, core activities are typically prescriptive processes that require specific properties and features to be recorded and reported with attributes, including location and time. As a simple example, locations of water sampling points, dates and times of sampling are commonly legislated metadata for chemical analyses. Reporting requires geospatial information management, presentation and interpretation that can be independently scrutinised. The crucial steps involved were (1) field collection of digitised geospatial information using a mobile device application under a range of GNSS signal degradation, (2) information transfer, file structure and conversion, database accuracy, merging and visualisation, (3) basic cartographic presentation, and (4) spatial analysis and proposal development including quantifying benefits of the proposal (Figure 1). Workbooks and prepared geospatial data sets are the basis of most introductory geospatial information science. However, this is atypical of field environmental science projects such as impact assessment, surveillance and monitoring, where location and attribute information field collected.

Within the constraints of a single Unit, priorities were: (1) consistent and accurate collection of geospatial data, (2) understanding obstruction and multipath GNSS error, (3) cleaning and repairing inaccurate records, (4) flexibility and problem-solving skills associated with management, transfer and analysis using multiple geospatial file formats, and (5) development of critical analysis of data quality and spatial analytical skills. These skills will be essential regardless of the software platform used in the workplace. These goals required students to collect authentic data in a scalable yet personally identifiable manner and to develop and manage geospatial datasets that were sufficiently large to allow geospatial analytical processing that relied on students' collected data.

Several weekly elements were introduced during the semester to reinforce the authenticity of activities.

1. Firstly, each lecture started with current environmental GIS positions in job listings and environmental GIS news items. The GIS-specific skills required or desired were highlighted and referenced to field, laboratory and assessment components. These included examples of field data collection and reporting (Fig 1-Assessment 1), database management and reporting (Fig 1- Assessment 2), and environmental risk assessments and non-compliance (Fig 1- Assessment 4).

2. Examples of industry standards for cartographic presentation of geospatial information, using contemporary (<5yrs old) environmental reporting for government and industry were regularly provided (Figure 1 – Assessment 3).

Providing a mobile mapping data collection component and giving students explicit experience of data type, geometry, coordinate systems, and file formats and management, it was possible to build on their basic experience and provide them with an authentic learning experience.

The mobile applications allowed the collection of point, line and polygon geometries. The applications allowed students to collect four attribute fields (two text fields, one integer and one float number field) with XYZ coordinates for each feature. Each record was saved directly to the students' personal drives. The applications did not allow map data entry and required students to add points at the location of the device. This limitation ensured that students collected features in the field rather than interpreting imagery base maps. They then presented their interpretation of aerial photography and manual digitisation of features in the third Assessment item (Figure 1). The site location also presented a range of GNSS obstruction and multipath environments that created examples of locational inaccuracy. A simple custom application provided students with an application that did not require software licenses, live data connections, servers or proprietary file formats and had equivalent functionality on both Android and iOS mobile operating systems. GeoJSON file outputs are easily implemented in mobile applications, human-readable and readily checked for uniqueness in automated plagiarism software.

A Botanical Gardens, adjacent to the campus provided a diverse range of well-labelled and structured, discretely located features, including labelled trees, seats, bins, playground equipment, signage and lighting. Data collection protocols provided as a table of fields and appropriate data ranges and types assisted student data entry. The first assessment item required students to collect, convert file formatting, and present geospatial data they had collected in both GeoJSON and tabulated attributes from shapefile format.

Geospatial data collection was first conducted in the second week of semester following lectures covering geospatial data formats, geographic and projected coordinate systems. All students collected a permanent survey mark on a nearby street corner. Students then collected several features within the City Botanic Gardens to gain familiarity with the software and basic data export. Focused 90-minute data collections activities in weeks three and four ensure collection of most necessary geospatial data with time to check progress each week. The formatting of data within the mobile applications was deliberately simple to maximise flexibility for the students while ensuring data management and quality control activities would be effective learning elements.

By introducing personal responsibility for data collection and preparation, students were motivated by the requirements for data collection and by the expectation of peers to deliver effective and accurate information for the class data set. By using an open access application associated with the Unit, students seeking high grades could independently validate and supplement data.

Throughout the semester, the geospatial analysis and interpretation tasks were scaffolded so geospatial information creation, management and analysis, learned previously, were re-applied with extension (Merrill & Reiser, 2019). Discrete geoprocessing workflows provided the specific goals of the activity as an information box at the top of the section. Common workflow steps were applied uniquely by each student based on personal decisions regarding data integrity and quality.

Evidence of student achievement and engagement with the Unit is presented using selected cohort results, and voluntary focus group responses at the end of the semester were analysed while student self-assessment is considered.

## Results and Reflection

### *Developing Authentic Learning*

A quality learning experience is challenging to measure, but there are several indicators, and completion of assessment items is one such indicator. Student completion of laboratory-based assessment items ranged between 62-65 out of 66 enrolled students. The first summative assessment required submission of personally collected data in week 5, resulting in 64 students submitting raw GeoJSON files. Collecting, transferring and converting geospatial information following field data collection is commonly required. Across the cohort, only 10% received maximum grades for higher-level geospatial information skills, such as detailed method reporting and measurement accuracy. The high level of attainment and near 100% submission rate demonstrates that data collection using a mobile application was readily achievable for this particular cohort of students.

Mobile apps used included a unique field to identify the data collector. This provided an additional database attribute that students could use to analyse contributions to mapping and sources of error. Personalisation of data collection has an added benefit of introducing students to search effort and measurement of population-level data collected in haphazard patterns. The class point feature records demonstrated class level bias in sampling, using spatial analytical tools in later laboratory sessions. The haphazard nature of the search effort resulted in a wide range of duplication rates in features. Introducing database querying and visualisation of duplicates reinforces the nature of GNSS location uncertainty and impacts of field methodology. All assessments required student assessment of data quality and accuracy. Understanding search effort and demonstrating the impact incomplete data collection is essential for field activities that report for statutory requirements, as these students will experience in the workplace. Recognition of features duplication and absence provided important feedback and discussion material for students in later assessment items.

Students developed the connection between personally collected field data and aggregated data sets as part of the second summative assessment. The assessment required them to convert comma-separated text into fields, convert GeoJSON to shapefile, and standardise attributes within each field. Where there was significant uncertainty in records, students were able to mark features for exclusion, providing an understanding of error rates and types. They were subsequently required to present their data cartographically to show their data relative to the class data set, with feature classes and identifiable errors. Tabulation of outlier features and comparison of spatial accuracy against a permanent survey mark, using the class data, were also required. In completing this assessment, students effectively developed their own unique but substantial feature layer.

Incomplete data sets are a reality of many environmental studies, so issues of missing or duplicated records were explicitly added to assessment items. In many instances, geolocated data sets are collected or provided by third parties. For students in this Unit, the experience of having to rely on data collected by others is an essential and authentic experience. The consequences of incomplete data for cartographic presentation and spatial analysis components is highlighted for each student, depending on the decisions made during attribute repair and cleaning. Because environmental scientists need to report using geospatial information they have collected, created, or that has been created for them, and may contain location, duplication and attribute errors, it is essential that students are able to identify, correct or remove such errors before producing reports. Informal communication with students indicated that database quality control and repair was disliked. Still, students agreed that managing locational and attribute errors were required to ensure accurate analyses in later stages. The Unit Coordinator also noted peer communication to identify the nature of errors and decisions to repair or remove data.

Student perception of teaching and learning quality is unreliable in determining teaching and learning quality (Boring et al. 2016, Uttl et al. 2017), and is likely to be further biased by the non-compulsory nature of feedback at the study's Institution. Effectiveness vs affectiveness of field-based learning is also difficult to separate (Fuller et al 2006). However, aggregate results are presented here as evidence of student interest and motivation in the Unit. Ratings were on a scale of 1-5 (strongly disagree to strongly agree respectively) for the following statements:

1. This Unit provided me with good learning opportunities.

2. I took advantage of the opportunities to learn in this Unit.
3. Overall, I am satisfied with this Unit.

Questions 1 and 3 are likely to be closely correlated while the second question represents a self-assessment of student effort. Results for this survey have been collected for six years representing four years of the prior approach and two years employing an explicitly authentic e-learning and student-centred approach. Response numbers, average assessments of learning opportunity and unit satisfaction were higher in both years of the student-centred authentic learning process than in any of the previous years (Figure 2). Student self-assessment of effort (Question 2) was the most stable metric recorded (variance 0.09 over 6 years). In the second iteration of this approach (2019) both learning opportunities and satisfaction with the Unit exceeded student self-assessment of effort.

{FIGURE 2 NEAR HERE}

Unsolicited student contact after final grades and assessment represents a smaller and still biased pool, but may nevertheless be a better indicator of effective learning. Student contacts after module completion have indicated that the GIS tools taught were useful. One email stated "[t]*his is the first subject I have taken that I can see how it would apply to a job.*" In the following semester the Lecturer received an email stating that two students had "*...both just managed to smash out a map each in ArcMap in just over an hour. Clearly you did something very right for us to still remember all the steps from creating a shapefile to fine tuning our legend"*. This provided evidence that students could apply the skills developed in the Unit to subsequent unrelated Units.

This Unit employed digital collection of feature attributes with geolocation to involve the students in the generation of the data that they subsequently analysed and presented. The first iteration of this approach was a straightforward and flexible interface without map. In 2019 a cross-platform application was employed that operated on a wide range of versions of both major operating systems (iOS, Android) and included a map display showing collected data.

Students who participated in the focus groups (one group of 9 students after the first iteration in 2018; one group of 5 students after the second iteration in 2019) clearly indicated that they initially lacked an appreciation of the importance of accurate data collection, especially the 2018 group. The data quality control required between 2-4 hours; however, the focus group respondents indicated that the importance of data quality assessment and verification of records were ultimately clearly understood, despite initial anxiety.

A report format including Executive Summary, cartographic figures, tables and clear conclusions was required for the Final Report in line with typical industry or government formats. The cartographic product was submitted as a single A1 size pdf document.

***Student Feedback on Learning***

Voluntary student feedback was collated from a focus group session in each year (2018, n=9; 2019, n=5), formal student surveys (2 per semester), and unsolicited email correspondence after semester completion. Whilst it is acknowledged that these communications are self-selecting and likely biased, response rates were higher than University averages (2018, 30% (n=20) vs 20.1%; 2019, 38% (n=32) vs 16.6%).

A focus group was conducted straight after the final exam with nine voluntary participants, who were all students in the Unit. The focus group aimed to explore student perceptions of the innovations that the Unit had introduced, and it allowed for reflection on their part. The focus group was conducted in a semi-structured manner, with one of the authors and another learning designer facilitating the discussion, broadly based on a set of prepared questions. Questions ranged from the general (e.g. What did you learn in this Unit?) to the specific (e.g. What did you think of activities you were required to engage in using the GeoApp?). The focus group was conducted following research ethics protocol, with prior university ethics approval. All participants were provided with an information sheet and all of them signed consent forms.

*Relevance of learning activities*

Participants talked about the process being rewarding and about "*the sense that you actually produced something when you do this*." The Lecturer reinforced this explicitly explaining the relevance of the activities to what you would do as part of an actual work context, including showing actual job adverts and the skills that employers asked for, something that was not lost on the participants:

> *I feel like I would be confident if I was told that I needed to do something like that in a job…like I would be able to…maybe be with a bit of revision…I would be able to do that, and also…like…give examples of where it would be used.*

Another participant, without being asked, brought up assessment as being *applicable to real life as well*, as the mapping of the City Botanic Gardens was seen as something that Brisbane City Council would do anyway, *so already the assessment you are doing is fundamentally useful in real life anyway*. Another student email after the semester ended related that the Unit was "*my first subject in spatial science, which I have come to enjoy and realise that* *these skills will help me in my future in environmental science.*" Related to this was a strong sense that they would be able to cope with analysing and addressing authentic problems.

> *I think the way that the Unit was delivered was that…given any sort of context that has a spatial element, you might be able to interpret it a bit and understand the issue that's going on there and maybe present a solution…at least be able to interpret fundamental real world problems with a spatial element.*

*The importance of good data*

Additionally, there was a realisation (an important learning curve in the Unit) of how important it was to have good data. The Unit Coordinator had therefore, deliberately built a process of data cleaning into the workflow of the Unit, which participants initially struggled with, but which they eventually really appreciated.

> *If he [the Lecturer] had just given us clean data, we wouldn't have as much of an appreciation for the process of collecting* good *data. And like…as frustrating as it was, it was good to go through that frustration.*

There was a sense that the importance of cleaning up data and working with clean data sets could have been emphasised a bit more from the beginning, even if that would not have alleviated the initial frustration.

*Student participation, motivation, and support required*

Interestingly, the participants noted that the workshops were long already (at three hours), but that most students regularly showed up to two hours early, *but you needed that time to actually do things*. The latter was partly because the software was only available in the lab, which was an issue, but at the same time, there was a deep appreciation of the fact that the Lecturer would always be there as well to assist when they would come in early. Forty-seven percent of all student feedback on teaching for 2018 explicitly included thanks for additional time spent in support (response rate 19/65 29%, University average response rate 20.1%). In 2019, peer demonstrators selected from the 2018 cohort were available during laboratories. Written student evaluations directly thanked demonstrators for their assistance in 52% of responses accompanied by an increased student satisfaction rating (4.7/5, n=32). Email and end of semester feedback included the following student comments:

"*I know that you came in to help us many times outside of paid hours, and that truly encouraged me to improve and continue learning.*"

The Lecturer has "*also gone to extra effort to make sure help is available by making themselves available outside of lab times…*"

*Authentic learning and assessment*

Creating and delivering authentic learning experiences and assessment increases the workload of teachers (Bearman et al., 2016, Karakaş-Özür & Duman, 2019; Mohamed & Lebar, 2017) requiring assessment of long term sustainability. However, the potential benefits may outweigh this. For instance, Villaroel et al. (2018) sum up the benefits of authentic assessment as follows: impact on quality and depth of learning achieved by the student; development of higher-order thinking skills; improved autonomy and motivation for learning; improved self-regulation capacity, metacognition and self-reflection (p. 841). These benefits were either specifically mentioned by focus group participants or noted in the Lecturer's reflections and expert peer reviews.

When asked about specific workplace skills they had learned in the Unit, participants mentioned the software first and foremost:

> *The software itself is the least intuitive thing I have ever seen, so just knowing how to use is definitely important for a range of different areas…like environmental science…for the government analysing data…arts as well…and science and geography.*

Another participant mentioned more generic skills, such as patience, persistence and problem-solving skills that can be applied to other software and other situations more broadly.

Participants were generally positive about the group work skills they had developed in the Unit, which they specifically related to activities around the GeoApp; *mostly understand what can go wrong and how to prevent it.*

> *Yeah, I think you could notice groups that approached collecting the data strategically to groups that didn't…people who didn't, they went out and all just collected stuff…but in our group actually using data that we collected was quite easy because we were quite strategic.*

Participants discussed at some length the applicability of what they had learned in this Unit, mentioning not only generic skills, such as group work and problem-solving skills, but importantly also spatial thinking. Students explained that this Unit had taught them the relevance of GIS and spatial thinking to other disciplines, from environmental science and biology to economics, management and experimental design. Both the Unit Coordinator and the Expert Peer Reviewer noted that students in both the 2018 and 2019 cohorts significantly improved in terms of their self-regulation capacity as well as their metacognition.

As a final comment, one of the participants said that *a lot of people ended up loving the subject, and want to work in this field now, so…*

## Discussion

The redesign of this Unit of study aimed to implement authentic learning and assessment, as described by Herrington and Herrington (2006, p3). Collaborative construction of the class data set creates an excellent simulation of the GIS and geospatial data errors encountered in graduate GIS science positions. Ill-defined activities such as geodatabase cleaning fit the requirements of highly authentic activities (Herrington and Herrington, 2006, p3). That this activity creates the data that students will personally use in cartographic products for clients in later assessments reinforces the sustained effort required to succeed in GIS associated projects (Bowlick et al., 2016). While the transformed module has an environmental science focus, module enrolments come from many other courses. As the Institution's sole Geography and GIS-based Unit in Undergraduate Science, a prescriptive approach using predefined datasets and known outcomes would reduce teaching workload at the expense of authenticity (Bearman et. al., 2016). A diverse selection of clients in assessment three opens diverse roles and perspectives for students (Herrington and Herrington, 2006).

Scaffolding and coaching elements of authentic learning were enhanced by introducing peer demonstrators, drawn from the 2018 cohort, to support laboratory sessions in 2019. Student appreciation of peer demonstrators may also come from improved the social construction of knowledge (Herrington and Herrington, 2006 p6), although this was not directly assessed. The focus group data suggest that authenticity was achieved to a substantial extent, as participants discussed a range of employment-related skills and potential applications of what they had learned in the Unit. Furthermore, ongoing contact with some students in the following semester has indicated that they were actively using the geospatial skills developed in the Unit to improve their work in other Environmental Science Units, which had already been foreshadowed in the focus group data. This provides a clear demonstration that students understood the nature of GIS as a tool kit and method of thought that can be broadly applied both to quantitative understanding and to cartographic presentation of information.

Interestingly, the focus group data also suggested that students found this Unit very challenging, especially in the beginning. However, they overcame their initial frustrations and ultimately became highly motivated and engaged in the learning activities in a self-regulated manner, albeit with significant Lecturer support. This is in line with what Hamari et al. (2015) have identified reagarding challenging games in higher education. Our results demonstrated that the workflows facilitated students in addressing problems in groups. This was explicitly related to authentic learning and assessment, as it was impressed upon students from the beginning that field environmental scientists will be in the field and collecting data; they will be given other people's data and have to clean and prepare data; and they will map and analyse data cognition of spatial processes and patterns. The surveys and focus groups suggest that students not only gained a clear understanding of the importance of these skills but that the authentic challenges presented motivated performance through the semester. The relevance of what they were learning for their future employment likely enhanced this motivation.

Mobile device applications were central to the success of the developed approach. These apps provided an accessible means for students to gather authentic data, unlike other units in GIS that provide clean data. Authentic data include missing data and duplicated records, which focuses students' attention on the importance of the search effort, or in other words, the process itself, which was again something that the students understood, based on the focus group data.

The Unit continues with development of mobile GIS data collection applications, as well as field and laboratory activities. Improving the structure of data collection and incentivising both collection volume and accuracy is possible when all students can equally participate in data creation. The Unit approach of teaching students how to learn GIS, as opposed to teaching rote

GIS workflows, was important in motivating students and engaging them in the unit activities. Selecting a public botanical garden for mapping activities provided many opportunities for workplace-relevant discussion regarding both environmental and social aspects.

**Conclusions**

The redevelopment described for this Unit drew on the Unit Coordinator's experience in industry and assessment of GIS skillsets sought by contemporary employers of Environmental Science graduates. All laboratory assessment items mirrored steps of a field project with strong geospatial information components. Students were required to take ownership of their data with the knowledge that their peers would use their data. Each assessment item built on previous work and data requiring students to maintain their data and providing additional exposure to the consequences of poor data management. Students developed a transferrable core set of geospatial information skills that include field data collection, data management and quality control, spatial analytical deduction and inference, basic cartography and quantitative spatial analysis. We present two successive years of teaching with this Unit showing that a student collected data foundation and workplace focused assessments are transferrable to larger cohort sizes. It is hoped that this approach may be tested across a larger number of students and activities to confirm outcomes, as well as potentially in a range of different contexts and with other student cohorts. Options for using to open data mobile applications may be as diverse as public transport or health, ecological or biological field investigations, air or water quality.

While many institutions provide tertiary education in geographical science, numerous other professions, including Environmental Science, rely on geospatial information and critical spatial thinking (Gharehbaghi and Scott-Young, 2018; Rickles and Ellul, 2014). While Bearman et al.

(2016) discuss the limitations on learning within a Bachelor's Degree in Geography, we seek to maximise student outcomes within the time constraints of a single Unit in a single semester. Designing a Unit as a single complex problem is not a new concept (Huang 2011, Bowlick et al. 2016) but requires scaffolding (Brickell 2006, Howarth and Sinton 2011) and significant investment from teaching staff. Providing students with functional workplace skills and foundation knowledge in <5% of a Bachelors Degree presents extreme constraints that we have sought to address by designing an authentic learning and assessment structure (Figure 1). Mapping a Botanical Gardens is unlikely to be a project for graduating students but presents an accessible field site that encourages critical spatial thinking (Ridha et al. 2020, Bearman et al. 2016). Student responses in focus groups, formal and informal feedback indicate metacognition of real-world skills and the critical role of GIS in biological and environmental sciences. We have shown the use of student collected data as the foundational GIS data source for authentic learning and assessment provides positive and productive student learning as the sole experience with GIS before entering the workplace.

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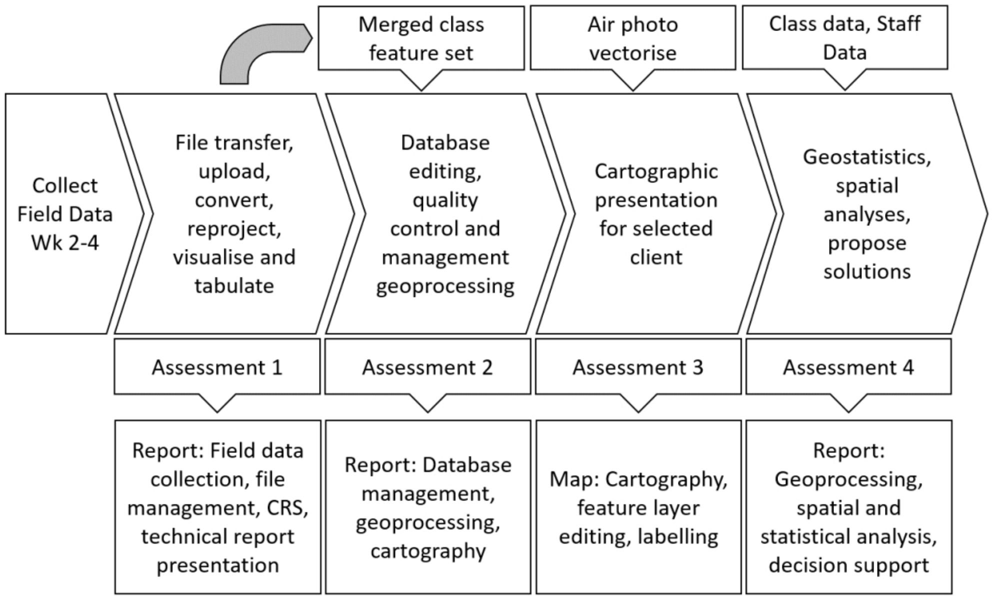
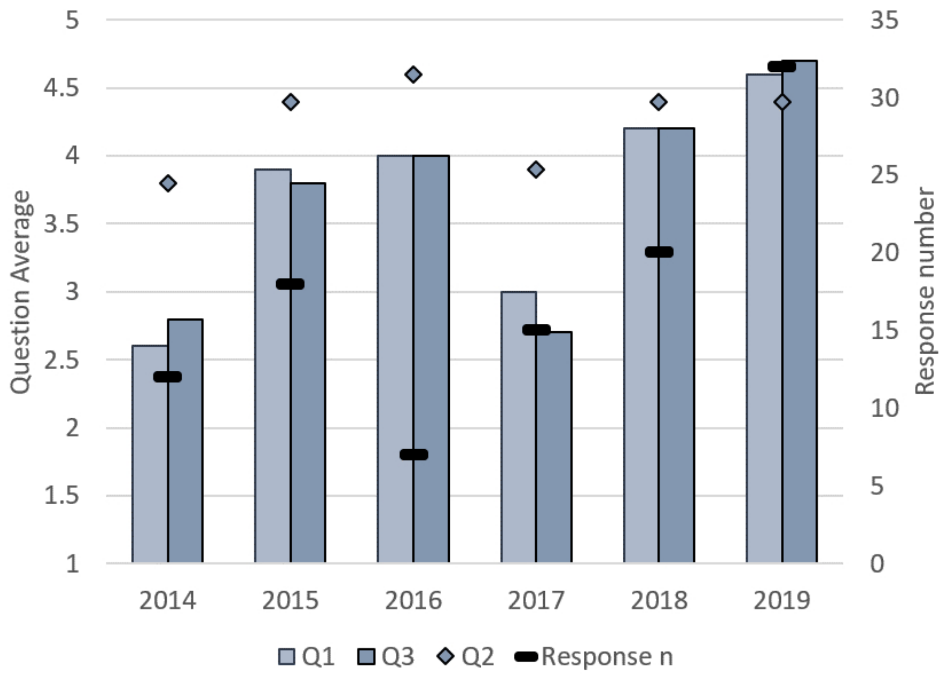
Table 1. E

| | Attainment (grade) | | Engagement (submission) | |
|---|---|---|---|---|
| | 2018 (65) | 2019 (87) | 2018 (65) | 2019 (87) |
| Field Data collection | 77.1 | 87.7 | 100 | 95.1 |
| Data Quality | 69 | 73.5 | 95.4 | 97.5 |
| Cartography | 74.5 | 79.6 | 93.8 | 97.5 |
| Exam | 70.2 | 61.3 | 95.4 | 93.8 |
| Analysis | 73.4 | 68.5 | 96.9 | 95.1 |




Structure of Unit assessment items and alignment to workflow of an environmental science field project. Four assessment items are in the form of reports and cartographic products.




Student survey responses including average response out of five for three core questions. Number number of responses is also reported over a six year period.

Reviewer Comments to Address.

Deadline for reresubmission: your revised manuscript should be **uploaded by 06-Sep-2020**

Reviewer 1 General Comments

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| This paper makes an interesting contribution to the literature on authentic learning however links with the literature in the discussion are very light. |
| Additional links have been added in discussion and introduction. The goal of an Authentic learning experience that delivers assessable outputs is hopefully clearly enunciated. |
| The authors rightly point out that student perspectives are a undeservedly smaller part of this literature and the paper makes a key contribution here but needs to explicitly acknowledge this contribution with reference to the wider literature and in outlining their contribution later in the paper. |
| The Conclusion section now explicitly states the outcomes of the paper. While much of JGHE is rightly focused on teaching in the geographical sciences, many institutions do not have geography degrees and many professions rely on geographical and geospatial information for routine work. This paper presents a single module in a single semester as the sole GIS experience students will have. We believe we have demonstrated a strong outcome within the constraints imposed. |
| Its good to see the replication of the paper for a second year but there are a few references which do not clarify what year or if all students are included in the evaluation of the approach (e.g. focus group of 9 students, one year only?: across the cohort (both years?): submission rates the same for both years? 62-65 of 66 enrolled students, 10% for both years? Etc.) The paper lacks a placement of authentic learning from the wider literature. Perhaps simply geography and related disciplines may be appropriate but a limit to ES only is to restrictive for the intended audience of JGHE. |
| Authentic Learning literature addressed in some detail now including discussion. |
| The paper would also benefit from a clearer communication of what the readers can gain from reading the article (possibly a clear research question or statement). For example, is it the design of the experience or the benefit of authentic learning from a student perspective or both? |
| Abstract and introduction have been rewritten. |
| The paper employs a good number of evaluation methods as suggested in much education literature but they are not clearly drawn upon, e.g, the lecturer's reflective journal, expert peer review of teaching. |
| Hopefully expanded. |
| Additional Comments Authors: |

Reviewer 1: Specific Comments.

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| 1. Abstract: Insert "assessment" before "requirements modelled…" | Inserted |

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| 2. Introduction: Unit - as this is not common practice across all tertiary institutions, It would be worth defining early (e.g. equivalent to a full course of X length. Students are expected to complete X units a year.) | Changed to: While many Environmental Science Units implicitly apply geospatial information, the Unit presented here is currently the only required geospatial information subject. The Unit is completed in thirteen weeks with three hours of applied workshops and one hour lecture each week. |
| 3. Use of commas – it would be good to see a more robust application of commas where appropriate (e.g. subclauses: "For most students, …") as they will make the text a lot easier to read | Grammar has been reviewed for the entire manuscript. |
| 4. Pg 2 line 9. The stated goal sentence does not follow from the previous narrative and is confusing. | The sub-sentence "which partly informed the Unit design." has been added, which is then followed by "Overall, the Unit..." so there is a clear transition. |
| 5. Supply reference for direct quotes from university document | QUT 2020 website URL provided. |
| 6. Unit should not have a capital (it doesn't in the abstract) | Unit is the Authors Institutional term for subject or minimum course element contributing to conferral of a degree. Unit has been capitalised throughout. |
| 7. "In Australia, environmental scientists are required…" IS this really the case as I am unaware of a professional body and accreditation? Often required may be more appropriate. | Reworded: In Australia, environmental scientists often collect both samples and geospatial information in the field to meet statutory obligations required for development and other potentially environmentally harmful activities. |
| 8. Pg 3 line 8 – personally? Please clarify by the students or lecturer? | Secondly, all subsequent laboratory activities and summative assessments used students' personally collected data or merged class datasets that students had personally cleaned. |
| 9. Pg 5 line 1 – who were the further suggestions made by? | Removed in addressing, 3rd general comment above. |
| 10. Page 6 line 21-22. This is not a definition of authentic learning and only applies to ES. A broader definition is needed as well as this operational and restricted definition. | Broader definitions are provided on pp. 6-7. This definition has been amended to read: In the context of geospatial information science and this study, authentic learning is applied as a pedagogical framework that is aimed at ensuring that students can demonstrate the skills and thinking required to deliver value across the dominant fields and industries that employ environmental scientists.<br><br>HENK? maybe this comment from 2019 SPOT" provided learning opportunities that can be directly applied to the workforce, and even went so far as to provide insight into current and future job prospects available on [S]eek on a weekly basis." |
| 11. The jump to "Thus, there is a student expectation that they will have access to authentic learning environments" is not supported by the preceeding paragraph nor appropriate references. | The following sentence and reference have been added: McHaney (2012) has noted that millennial students are purposeful people who seek relevant skills and knowledge that are taught efficiently while giving |

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| | them a meaningful experience. This suggests that these students have an expectation that... |
| 12. More recent research shows that most students are happy to use their own mobile devices for learning – please explain relevance and alternatives | Historical instances of this Unit used a limited pool (<10) of institutional devices such as the Garmin eTrex. This effectively limited each student to collecting several features during class. This approach was inadequate for the goals of the redesigned Unit because students are unable to demonstrate their ability to collect field data, repeated measurement of feature location is impractical and it is impossible to collect sufficient data to allow student database management and cleaning. |
| 13. Sentence "While some researchers see themselves belonging to either a QUAN .." is superfluous | deleted |
| 14. "The mixed methods approach was inserted into a case study format" what does this mean? | **Changed to:** This mixed methods approach was part of an overall case study format (Yin, 2011). |
| 15. Clarify "the unit is not a prerequisite third level study" – do the authors mean required here? | "It is not a prerequisite for any higher level Units, so enrolments included students starting second year (3rd semester) to final semester (6th semester) of undergraduate study. Enrolments were sixty-six and eighty-five in 2018 and 2019 respectively with 52 hours of contact (1 lecture, 3 laboratory) over a 13-week semester." prerequisite is used to denote a subject that must be completed prior to undertaking more advanced topics. Completion of the presented Unit is not required for any other Units at the institution. |
| 16. "Laboratory-based assessment items were mapped onto a generic Environmental Science project framework providing authentic context" Please clarify as this is not clearly supported by Figure 1 | Changed to "Assessment items follow a generic Environmental Science project framework commencing with the collection of field data for target features (location, attributes), data quality control and preparation following transfer from devices, visualisation and analysis and finally decision support (Figure 1). This workflow formed four assessment items submitted by the students:" |
| 17. Figure 1 – nicely communicated assessment structure and well supported by the text on page 10 lines 1-12. | |
| 18. This aligns 'with' page 10 line 20 | 'with' inserted |
| 19. Suggest adding in what it specifically refers to - e.g. H, P and B-J's nine elements | |

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| 20. Are these the only elements included in this authentic learning? Where else have they been incorporated? | |
| 21. Error not earor | Spelling corrected. |
| 22. Suggest linking page 12 lines 6-14 to the assessments explicitly – e.g. parts of Fig 1 | "Several weekly elements were introduced during the semester to reinforce the authenticity of activities.<br>1. Firstly, each lecture started with current environmental GIS positions in job listings and environmental GIS news items. The GIS-specific skills required or desired were highlighted and referenced to field, laboratory and assessment components. These included examples of field data collection and reporting (Fig 1-Assessment 1). Database management and reporting (Fig 1-Assessment 2). Environmental risk assessments and non-compliance (Fig 1- Assessment 4).<br>2. Present examples of industry standards for cartographic presentation of geospatial information using contemporary (<5yrs old) environmental reporting for government and industry (Fig 1-Assessment 3)."<br>*Author Comments: These were opportunistic examples using current news articles or job advertisements. Depending on the job or news item the features highlighted vary. For example, Consulting jobs often place a premium on field travel and data collection/sampling. Industry positions often focus on database management and accurate recording. News stories often include cartographic products. Government positions reference analytical skills with regard potential non-compliance.* |
| 23. While a justification for not using base maps is provided – it goes against the authenticity of the experience and should be explicitly addressed | *Authors: We disagree with this comment. Many/most environmental study sites in Australia lack remote sensing data at sufficient spatial and temporal resolutions to allow desktop assessment. In addition, numerous environmental criteria are not remotely sensible (common native vs invasive species). These data inherently rely on a person recording location and attribute in the field. An additional sentence is added to clarify:* "Students present their interpretation of aerial photography and manual digitisation of features in the third Assessment item (Figure 1)." *In addition, the study area is a Botanical Garden with approximately 50% tree cover, aerial photographic* |

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| | *interpretation is of limited value in this instance. (Google Maps link https://goo.gl/maps/R1nmQLQVTK8CmzCE7 ) The following sentence in the manuscript also highlights the value of recording features based on device location for quantifying error associated with obstruction and multipath.* See Appendix R1.23 |
| 24. Page 16 line 4 – how does this relate to the assessments in figure 1? | "Students developed the connection between personally collected field data and aggregated data sets as part of the second summative assessment (Figure 1-Assessment 2)." |
| 25. When could the students use secondary data? For cleaning? | *Authors Comment: Yes, the study location is captured in high resolution imagery several times a year. Students were also provided Open Street Map download workflows. But, see comment 23 above.* |
| 26. When significant uncertainty… please give a concrete example | *Quantified as follows:* "Students were able to mark records for removal where attributes were missing or out of range, and where location records were outside the study area." |
| 27. Page 18 line 4 – how many students? | What do they want? A count of emails with dates and student grades? |
| 28. Page 19 line 9. How exactly has the student standard improved? Can this be supported through any of the methods employed for evaluation of the course? | Removed in changing to a paper focused on Authenticity |
| 29. Figure 3? Not 2? | Figures removed. |
| 30. Pg 20 "one student drew on canopy cover" using what? On what? | Statement clarified: "One student included intersection analysis of projected canopy cover and current seating distribution to justify installation of five seats within the Botanic Gardens (Figure 3)." |
| 31. Should kriged be capitalised? | Capital removed |
| 32. Pag e21 – what year was the focus group? both years? | The following has been added on p. 21: (one group of 9 students after the first iteration in 2018; one group of 5 students after the second iteration in 2019) |
| 33. Remove Thus page 21 line 16 as it doesn't automatically follow | removed |
| 34. Page 22 line 9 – "only needed to reproduce textbook materials in an exam" this is not supported by a quote – is this really true? Surely, they have to extend the material as well | Historical exam was 50 multiple choice questions, restricted to the lecture content. The sentence has been removed. |
| 35. Page 23 line 4 – deep appreciation – support required | Added evidence: "Forty-seven percent of all student feedback on teaching for 2018 explicitly included thanks for additional time spent in support (response rate 19/65 29%, Global University average response |

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| | rate 20.1%). Email and end of semester feedback included the following student comments:<br>"I know that you came in to help us many times outside of paid hours, and that truly encouraged me to improve and continue learning."<br>The lecturer has "also gone to extra effort to make sure help is available by making themselves available outside of lab times…"" |
| 36. Page 24 line 4 missing text? | Repaired |
| 37. Page 24 line 6 – university's real world learning strategy not previously discussed and requires reference – although not convinced it should be included here | Removed. |
| 38. "page 24 line 8 – just supported by the focus group? | Additional student response added. |
| 39. Spell out CS in conclusion page 26 line 15 | Spelled out. |
| Table 1 – include absolute numbers in the column headings | Total enrolled student numbers added. |

Reviewer 2

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| The teaching innovation presented here is novel and undoubtedly reflects an authentic assessment which is what the educators hope to achieve. The quotes show that students clearly enjoyed the assessment and the educators should be commended for their approach. A number of clarifications have been made about what exactly the students are required to do for the assignment which is beneficial for the reader. However, I still have some reservations about the way in which the innovation has been evaluated and some of my original reservations and suggestions have not been addressed. |
| The manuscript now clearly provides the limitations of the presented study. Feedback from graduates now working in Environmental Science were not included due to ethical considerations. I am providing one recent comment here as an example "*Had I been towards the start of my degree I would've definitely done GIS major or at very least minor, and being in industry even for a short time I can recognise it's extremely useful.*" -SB August 2020. I hope that the context of this work is now more clearly placed in Authentic Learning literature. The fundamental problem of gaining feedback from students in non-compulsory settings combined with short contract lecturing mean that it is not possible to build longitudinal studies at this institution. |
| On page 8, line 21, research questions are mentioned but these need to be much more clearly stated in their own section and referred back to throughout the discussion. The discussion seems to focus more on the engagement of students which isn't (as far as I can see) what the project set out to do as the research questions ask "whether the design of the unit worked, or in other words, whether it led to a quality and authentic learning experience for the students involved". If engagement is a key research question within this topic, you need to ensure that is embedded within your literature review, research aims and then use a greater range of qualitative data from the focus groups to support the quantitative metrics. You mention 'engagement' once within the focus group discussion but additional qualitative quotes are needed to support your point here. To further support 'engagement', it would be useful to include the previous 4 years of data (prior to the |

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| innovation) in Table 1 for comparison, that would help to demonstrate how engagement has changed because of the innovation. |
| The following explicit research question has been added on pp. 8-9: The research question addressed in the case study is: How can authentic learning and assessment design be applied to develop both students' expectations around employability and their employability itself in a geospatial information science Unit? Student engagement has been removed as a focus throughout the paper. |
| I suggest that the 'focus group discussions' section should be broken down into further sub-headings so that themes are immediately clear to your readers. Though mentioned in the methodology, I am still unclear where the teacher reflections and expert peer reviewers are within the results. If you have not included these results, please remove these statements from the methodology or please make it explicitly clear where these are embedded in the results section. The discussion would benefit from a greater body of literature to support your findings in the wider context of the field of authentic assessment (and engagement; if you decide to focus on that as a theme). |
| Four sub-headings/ themes have been added to the focus group section. Where discussion relates to reflection of the Lecturer and Expert Peer Reviewer, this has been explicitly stated. Additional literature related to authentic assessment has been added to this section. |
| Overall, I feel that once the research questions are clear and linked to the results and discussions carefully, if additional qualitative data is used to support your points e.g. engagement and a greater body of literature is consulted to support your findings in the context of the wider field, this has the potential to be a useful addition to the 'authentic assessment' field within the geoscience community. |
| We believe we have now achieved this. |

**Appendix:**

Additional information 1

R1.23 Fourth map constructed by student showing light features from the class dataset. Air photo provides the interpretation of light locations. Lights labelled with asset codes, 1SD ellipse show impact of dense tree canopy and high rise buildings on location accuracy.