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Proceedings of the 12th Annual CITRENZ Conference

Editor: Dr. Emre Erturk

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Dr Emre Erturk

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Computing and Information Technology Research and Education New Zealand (CITRENZ) was formed as an organisation in 2010, as a result of an expansion of the National Advisory Committee on Computing Qualifications (NACCQ), which dates back to 1988.

CITRENZ provides help and support to member institutions in the development, teaching and quality assurance of courses and programmes, from certificate through degree to postgraduate levels, in the field of Computing and Information Technology.

CITRENZ has supported academic staff in several different ways, such as workshops, panels, research seminars, assessment of prior learning, moderation, the publishing of a separate academic journal (i.e., http://www.citrenz.ac.nz/jacit/about.html), and by organising this annual conference. The philosophy of the conference is the encouragement and support of new, emerging and established researchers in a safe environment while encouraging excellence and academic discourse. The fellows of CITRENZ include Dr Stephen Corich, Professor Sam Mann, Garry Roberton, Dr Donald Joyce, Keith Cowan, Chris Goodyer, Assoc. Professor Alison Clear, and the late Noel Bridgeman.

In 2021, the conference has been held not only under the auspices of IT Professionals (ITP) New Zealand but also on the ITP premises for the first two days, followed by the third day at the Te Papa Museum, together with the ITx Innovation Day in Wellington. More information about ITP: https://itp.nz/About

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Theme

The conference invited presentation proposals in the following areas this year (along with the regular sub disciplines and trending topics in Computing and IT):

- Computing and IT Education
- Applied Technology Research
- Agile Development
- Innovative teaching and engagement during the 2020-21 COVID lockdown

Papers and Abstracts (Peer Review)

Prior to acceptance and presentation in 2021, paper abstracts (proposals) were refereed by two reviewers. Full papers were double blind refereed on submission by at least two independent reviewers. They could be rejected, or returned for modification. Before 2020, mainly full papers were expected. As the negative impact of the global pandemic decreases, a greater proportion of full papers is expected in the future.

Posters

Posters and their brief abstracts were reviewed by the conference organising committee. Printed (full size) posters were displayed at the conference venues.

Online

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Special Interest Group Meetings:

Five Special Interest Groups - with nation-wide participation: Learning environments, Software Development, Infrastructure, Postgraduate, and Pre-Degree Programmes.

Special Workshop: Kaupapa Māori Approach to Teaching Computing: Held by Dr Blaine Rakena and Hamiora De Tomo on 14 July.

2021 CITRENZ Awards

The paper awards were judged by the Editor, also by consulting with others and based on the peer reviews. The criteria for judging the papers include relevance to CITRENZ, originality, structure, format, scholarship, and methodology (and relevance to the category in question, if applicable). In 2021, the evaluation was based on the papers or proposals, and presentations.

The posters were judged by popular vote at the venues, and by the Editor based on research, creativity, and their categories. CITRENZ provides gifts for awarded papers and posters and can provide certificates when requested.

Best Posters:

Winner (Popular Vote): Joshua Undrill and Bernard Otinpong, Ara Institute of Canterbury: "Developing a Mobile Application for Ara's Artworks"

Runner-up (Popular Vote): Terry Jeon, Richa Panjabi, and Clement Swarnappa, Weltec: "The Impact of Covid-19 Lockdowns on the Learning and Teaching of Tertiary Learners at Wellington Institute of Technology, New Zealand"

Commendation: Eastern Institute of Technology, the Taradale and Auckland campuses for providing additional unpublished (no abstract) student posters

Awards for Papers and Presentations:

Most Original Educational Practice
(improving educational outcomes)
"Studio in the Bachelor of IT" Elise Allen, Otago Polytechnic

Excellent Collaborative Presentation
(research project conducted together with industry)
"Forming Teams for Cybersecurity and Cyber Forensics operations"
Prashant Khanna and Chris Baker, Wintec and PeopleMaps

Commendation – Emerging Researcher
"Why don't Girls Study IT? Redressing the Gender Imbalance in the Information Technology Sector"
Arifah Addison, Ara Institute of Canterbury

Excellent Presentation (Completed Work and Vocational Potential
"Power Supply Dynamics for Outdoor IoT Sensors"
Steve Cosgrove and Mathew Way, Whitireia and Econode

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Work Integrated Learning in Information Technology: Reflections from a Public Institution.

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Abstract

Work Integrated Learning (WIL) capstone projects can have a significant impact on stakeholders including students, institution, industry, and discipline. Capstone projects provide an avenue for students to enhance their learning experience, build confidence in their skills and abilities, and potential work opportunities. For the department, it reinforces the notion that academic activities relate meaningfully to the industry by bridging the gap, and project deliverables can further enrich the student's grasp of the discipline. For industry, capstone projects can be a useful experience offering solutions in the real world and saving organisations time and money. Information technology (IT) students in the last semester of the degree programme at Ara Institute of Canterbury must undertake a WIL capstone project requiring them to carry out a major piece of work together with full documentation of their experience and a panel presentation. In this paper, we highlight the WIL capstone model used by the Department of Business and Digital Technologies at Ara in which students apply a wide range of technical skills as well as enhance their soft skills through authentic learning problem-based projects. It also reports on the observed benefits and challenges of WIL capstone projects from more than 20 years of experience at Ara. The feedback from stakeholders strongly suggests that capstone projects boost students' engagement, skills and knowledge, offer a competitive advantage in gaining employment with project sponsors and other industry employers. On the other hand, WIL capstone projects have been criticised for their tight assessment schedules and completion times. Future work looks at how to address some of the challenges noted by stakeholders and make recommendations on how the WIL capstone current design can be adjusted to a changing world.

Keywords

capstone projects, Work Integrated Learning, independent learning, authentic learning, project-based learning, student-centred learning.

1. Introduction

Many institutions build experiential learning opportunities into their curriculum through Work Integrated Learning (WIL) programs, where students work on projects for the industry. The format of these projects varies in many situations with some commonalities, such as undertaking these projects in the final semester with an industry mentor (Schachter and Schwartz, 2009). Schachter and Schwartz (2009) also noted that WIL

projects normally take from a semester (six months) to year-long courses and often occurs during the final year of study and aim to provide students with real world industry experience in their chosen areas of specialisation. Some researchers have examined Work Integrated Learning (WIL) from different perspectives including industry and academic successes (Mann and Smith 2006) and challenges involved (Howe, Poulos & Rosenbauer, 2016). WIL projects fall under the umbrella of cooperative education which combine classroom-based education with practical education upon which relationships are formed between students, industry, and institutions. The nature of the relationships can vary depending on the discipline and the structure of the Work Integrated Learning experience (Zegwaard & Coll 2011). In most computing projects, there is a strong bond formed between various stakeholders. For instance, developing a software product requires a cycle of requirements, design, analysis and implementation phases that inevitably involves feedback, discussion, and refinements.

Chamillard and Braun (2002, p. 227) argue that "*the most critical aspect of the (software engineering/capstone) sequence is the use of real projects, with real customers*". Bruhn and Camp (2004) describe the benefits of capstone projects as a "win-win-win" situation for all. Some benefits include students gaining professional skills, and the industry receiving solutions that save resources and money. Furthermore, the industry mentors get the opportunity to serve as guest lecturers, curriculum advisors, design project sponsors and team mentors. Lastly the faculty engage students in meaningful work integrated learning projects that prepare them for transitions from academic theory to industry practice.

Jackson (2015) also points out that close working relationships between the industry mentors, faculty and student are central to successful outcomes. Those relationships make it possible for supervisors to ensure capstone projects are organisationally meaningful, to remain involved with the student throughout the semester, and to solve problems that improved the project as it developed. Student professionalism is difficult to predict without exposure to a workplace (Hodges and Burchell 2003), and WIL projects are helpful by placing students in a work environment.

In research specific to capstone projects, Schachter and Schwartz (2009) found the industry were more satisfied with capstone projects that developed products or applications than with those that did not. The authors also report that the industry was more satisfied with WIL projects that involved an assessment component that involved them. While there are many benefits to capstone projects, they are not without challenges. Managing expectations from industry partners can also be a daunting task due to differing objectives. Some researchers have reported tensions between students, academic staff and industry partners about student's learning the "process" of capstone (requirement, analysis, and design) and the final "product" (the deliverable artifact). As an educational outcome, most capstone courses emphasise process rather than the final product or outcome (Howe, Poulos & Rosenbauer, 2016). However, the industry partners in many ways have more interest in the product as it directly impacts them.

2. Capstone WIL Design

The capstone WIL project course in the three-year Bachelor of Information and Communications Technologies (BICT) and the preceding Bachelor of Business Computing (BBComp) degree at Ara (previously Christchurch Polytechnic Institute of Technology) has been an integral component since its inception in 1996. The course is offered each semester and is usually undertaken in the final semester of the degree.

Course enrolment recently has been approximately 70 students each year. The course has a loading of 45 credits (equivalent to 450 hours), which is 75% of a full-time workload of 60 credits. The WIL industry project proportion of the course has a work commitment from the student of approximately 300 hours with up to 150 hours available for the academic outcomes. The project requires the involvement of an IT professional as the Industry Supervisor (IS) and a member of the IT teaching staff as the Academic Supervisor (AS). In addition, the course has an academic staff member in the role as the Course Convenor/Supervisor (CC).

Over the semester the students are required to attend tutorials on a range of topics related to both the conduct of the project itself and the associated academic outcomes. A recent change to the course design has them attending two 2-hour sessions per week during the first 5 weeks, and once a week on designated weeks thereafter. Students are assigned an AS at the commencement of the course who they are expected to meet with on a weekly basis throughout. Prior to the start of the course students are encouraged to begin to identify and contact prospective industry clients in the area relevant to their specialisation pathway, with assistance from the academic staff. Industry sponsors interview interested students, who often have more than one potential project they are interested in. Approximately 90% of the projects are industry sponsored with the remainder mostly proposed by academic staff and some by students. Typically, around 40% of the industry sponsors will take more than one student for one or more projects, however, each student has their own deliverables that they are expected to work on.

When an appropriate project is found, the student needs to complete a Work Integrated Learning Agreement form with signoff from the industry sponsor, the student, and the WIL course convenor. The student then works with both the Industry and Academic Supervisors to create a project proposal that becomes a formal agreement of the work they are committing to do, both for the IS/Client and the AS. During this phase, which in our experience may take students up to 4 weeks, the industry sponsors and academic staff can clarify and help the student articulate the project and course deliverables as well as the expected milestones and deadlines. The proposal contains the project details, scope, course and project management plans, stakeholder management, student skills, risk management programme, quality assurance programme, methodology, ethics, sustainability, inclusive practice and Te Tiriti o Waitiangi. It is summatively assessed by the CC and signed off by all the stakeholders (IS, student, AS and CC).

During the first half of the project, the in-scope and agreed industry deliverables are completed as appropriate. Towards the end of the first half of the planned duration, a

halfway progress report is created by the student (as an extension of the original proposal) and submitted to both the IS and AS, who both provide formal assessment and feedback on it. This halfway point assessment allows for updating of the project documentation incorporating any renegotiated deliverables and scope changes. This allows for over or underestimation of the initial set of deliverables, and any changes in scope that are a necessary consequence of work completed. Then over the second half of the project, students focus on the remaining agreed deliverables.

As the project concludes, the student confirms the completion of the outstanding deliverables and submits a final project report, methodology essay, poster and poster short paper, and creates a panel presentation. Each student has a final oral presentation and panel examination attended by at least the IS, AS and CC. Each individual student performance is assessed against their project completion, skills and professionalism, project and course management, quality assurance programme, risk assessment programme, methodologies essay, final report, analysis of relevant courses studied, project poster and short paper, their oral panel presentation, and responses to panel questions.

The grading of the project and course deliverables are based on the guidelines and rubrics for each of the deliverables. The rubrics and guidelines are discussed with, and made available to, the students in the first week of the course. The marking of the outcomes relates to meeting standards expected by both the industry and the academic institution. An unsatisfactory attempt with little evidence of work or understanding would result in a low mark. An exceptional outcome that exceeds the standard considered satisfactory and displays in-depth understanding or application of skills will receive the highest mark. The rubric allows for a range of achievement from a zero to 100%. The panel assessor's discussion results in a consensus awarding of marks for each of the outcomes for each student. Fifty percent of the marks awarded are directly based on the industry project outcomes to ensure quality standards were met during the project. Many of the other deliverables and outcomes that are awarded marks are also consistent with best practices required for IT project management.

Each semester, a poster exhibition displaying students' work in the capstone WIL project is held at the institute. Furthermore, this exhibition includes an event with attendance by a broad range of stakeholders celebrating the excellent work of the students, the input, guidance, and mentorship of the supervisors from both the industry and academic teams, and the support from the students whānau (family) and friends. An independent panel judges the posters and makes an award.

3. Benefits to Students, Industry and the Institution

The WIL programme has been designed to maximise the potential for several benefits to be realised. These benefits apply to the students involved in the project, the industry for whom the student is doing the project, and the institute who is coordinating the programme. The benefits should be considered intangible in that they are not directly

quantifiable as they are made up of perceptions, attitudes and experiences gained. Nonetheless, these benefits are considered essential to the overall success of the programme.

For the student, the WIL programme provides an opportunity to build on what they have learnt in the classroom by applying it in an industry context. There is no substitute for experience gained by working in industry. So, while the institute prides itself on delivering content in a way that at best simulates industry practices, the WIL programme brings a new dimension to the students' Capstone WIL learning. For example, in class students can be encouraged to work in groups to deliver to assessment requirements. While this mechanism can give students exposure to working with others, the academic nature of the assessment (such as grades being given) means that it is not a full reflection of an industry environment. Students have reported that by working in an industry environment, the gains in experience have improved their confidence in their own abilities. For example, one student stated, "*After the completion of this project, I feel confident in the direction I am heading and my abilities, not just as a computer networker, but as someone who can adapt and step out of their comfort zone, and that when I am faced with new challenges I can do well and even thrive*." This quote is representative of other students reported experiences.

Industry mentors and clients reported, that being able to provide a student with these opportunities to build on their classroom experience and develop their confidence is valuable because they have a unique opportunity to learn about the student, while witnessing and being involved in their project journey. This has twin benefits in that, on one hand, the industry client can be seen to be giving back to the community because they provided a real-world placement. On the other hand, the industry engages in a semester-long interview with the student, with no prior guarantee of a job at the conclusion of the work. In other words, try before you buy, with no commitment to buy. For the industry, this is a win-win situation, and this is not even factoring in that the work is being done for little or no additional costs, certainly not the full cost of employee renumeration. Furthermore, the financial benefit to the sponsor can be substantial with one recent project with a local start-up saved the company "$340,000 in quoted data costs". These findings align with Mann and Smith's (2006) work on a value proposition model for computing capstone projects.

The reputation of the institute and its standing as a provider of work-ready graduates is significantly linked to the success of the WIL programme. This is especially the case in the current tertiary provider environment where private institutes and universities exist alongside a newly centralised Institutes of Technology & Polytechnics (ITP) sector. The student is both a representative of themselves but also an ambassador of the calibre of students that the institute can provide. It is therefore in the institute's best interest to have programmes that prepare the students for the WIL experience, and for ensuring their success during the placement.

The institute can mitigate these risks by establishing a partnership with industry to ensure a pipeline of ongoing projects, but also to ensure the match with the student is a successful one. The strength of the WIL programme is that these partnerships do indeed exist. Some partnerships have been in place for more than 20 years and have resulted in many graduates being employed in their first full-time position by the project sponsors. For the staff at the institute these partnerships have the added benefit of exposing the staff to current industry practices. This means that the staff can update their case studies and ensure the content stays relevant for the student. For example, as the agile method of DevOps evolves into common accepted practice, the staff at the institute can observe and learn from the students' experiences and bring it back into the classroom. An additional benefit is that several graduates now working in the IT industry and industry practitioners are willing and able to make direct contributions into courses taught in the programme.

4. Challenges associated with the WIL Projects

For most students, WIL projects offer the best opportunity for them to get involved in real world projects, and to some it is the biggest project they have ever been involved in. This comes with some challenges. Finding a consistent stream of projects that are at the appropriate level for final year-level students can be challenging; academic staff need to often engage with industry to source projects throughout the year, and this can be time consuming. Some industry mentors have critiqued the duration of the WIL projects, which is a semester long (19 weeks) if students have a significant delay in commencement of their industry project work. This is because the WIL courses require students to focus on a variety of professional behaviours, including teamwork, conflict management, customer service, and project management along with their technical skills and a late start in a semester is considered problematic.

The WIL Agreement protects the industry providers' rights, especially in terms of intellectual property and non-disclosure. The student may also be required to sign industry agreements with additional requirement schedules. The student will confirm with the Industry Supervisor the nature of the material they can present for public display. During the individual student panel presentation, material not for public display can be presented under the acknowledgement of confidentiality agreed by the Academic Supervisor and Course Convenor.

The conduct of the WIL project usually requires office space and necessary resources are provided by the sponsor to enable the student to be fully integrated with staff in the organisation and provide a supervisor who should be a practising IT professional who can direct and mentor the student as they tackle the project. The IS also participates in a halfway assessment and the final assessment panel of the student. Ensuring prospective sponsors have appropriate facilities, personnel and understand their commitment to the WIL processes, requires proactive engagement by the academic staff and course convenor. The industry sponsors need to understand the student time commitments and time frames and ensure they allocate appropriate time for agreed student meetings and supervision. They also need to understand their obligations in relation to the student being

treated as if they were a worker, with the implementation of relevant policies and procedures including workplace health and safety and ethical guidelines.

The current semester timeframe gives the students a total of 19 weeks from the course start to its finish date. There are some students that need additional time due to unforeseen personal events and we can approve an extension for up to 6 weeks to allow the student to finish their projects and complete the course requirements. In addition, students with specific disabilities may require the project course to be run over the equivalent of 2 semesters. This has also applied to a small number of students who were in fulltime employment and the project work was an additional time allocation that was not achievable in a single semester.

The COVID-19 New Zealand lockdown in semester 1 2020, had a major impact on several projects. Some students had begun their project work and the industry sponsors were unable to proceed. This resulted in several students receiving deferment to semester 2 and they were able to either recommence or undertake a new project. The current course design can meet the need for extended duration, but this is currently treated as an exception. In addition, a hybrid work model that has both a physical and virtual presence became an accepted practice amongst some project providers. The institution has provided a project workspace that can act as a proxy for the office environment for those students who lack a suitable home-based working environment.

We are mindful of the unsuitability of some students for placement with industry sponsors. Active management of the placement opportunities with industry partners by the academic team is undertaken to ensure our long-standing relationships with partners remain intact. At the same time, we will give students who may not be suitable for industry placement meaningful internal projects that simulate the workplace expectations and environment.

An equivalent to the external IS will be allocated from the departmental academic team. This is in line with the New Zealand Code of pastoral care for domestic students enacted on 1 January 2020 (Ministry of Education, 2020).

5. Conclusions

Several researchers and stakeholders identify benefits associated with capstone WIL projects. These include students' integrating and applying technical knowledge and skills acquired in their years of studies and using a variety of professional and project management skills to execute successful projects. At Ara, the problem-solving capstone WIL project experience requires the students to demonstrate the application of these wide-ranging skills and has a major emphasis on the delivery of a solution for the industry sponsors.

Current trends in the IT industry and education also require us to design capstone WIL projects to meet the ever-changing demands of our stakeholders. At the same time, we continue to respond to industry trends and demands, and utilise feedback from our

students to adapt the degree course content to enhance the capstone WIL experience. The opportunity to have industry professionals and graduates to provide input into various topics within our courses is invaluable.

Although capstone WIL projects can be challenging, it can be very rewarding to stakeholders and remains one of the best forms of evaluating students' performance against how they have applied what they have learned. A large number of the industry sponsors have been providing projects and employing the graduates for many years. This indicates ongoing industry endorsement for the capstone WIL project course.

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The Cloud, the Curriculum and the Classroom: The Case of AWS at one Public Tertiary Institution

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Abstract

Over the past ten years, the cloud has transformed the way organisations use technology and do business around the world. For that reason, educators cannot ignore it, nor avoid making space for it in the curriculum. At the same time, it presents unique challenges, both philosophical and practical. It means educators having to ponder profound questions of academic integrity and independence on the one hand, and industry relevance and work readiness on the other. This gives rise to dilemmas and conflicts of interest. For instance, are educators partial to one cloud provider over another based, not on objective criteria, but on the quality of provider involvement and support for the curriculum? Whatever the decision, academic staff inevitably find themselves having to contend with an environment, over which they have little control and is subject to rapid, even unpredictable change. Moreover, they need to minimise financial risk and find ways of protecting themselves, their students and their institution from the cost of learning activities in the cloud.

This paper outlines the interest of AWS in tertiary education, and how this compares with making use of the course content of the authors' own institution at a time when no other vendor content was available. Using AWS course materials means no longer having to be responsible for updating course content, including working labs and projects. In addition, with the advent of greater unity in the institutes of technology and polytechnics (ITP) sector through Te Pūkenga, third-party course content does offer a common unified (at least formal) curriculum that industry endorses and supports. In short, this paper documents the journey of one public tertiary institution's use of AWS course content, and then goes on to suggest how it can best support and enhance teaching and learning within conventional diploma and degree programmes.

Keywords

AWS, cloud, academy, curriculum, course

1. Introduction

Tertiary institutions around the world have incorporated third-party vendor curriculum content into courses for many years. This content includes technical explanatory book-like notes (usually in electronic format), lab instructions, a lab environment, whether it be actual virtual machines, software tools, access to cloud services or a combination of the three as well as forums and certification, and other forms of instructor support.

This quality assured paper appeared at the 12th Annual Conference of Computing and Information Technology Research and Education New Zealand (CITRENZ 2021) & 34th Annual Conference of the National Advisory Committee on Computing Qualifications, Wellington, July 14-16 i.c. with ITx 2021

The vendor usually provides an agreement that outlines the nature of the academy programme. This is mutually beneficial. Vendors like Microsoft, Cisco, Red Hat, Amazon Web Services (AWS) encourage students to become knowledgeable and skilled in their tools and technologies, while tertiary institutions can assure students that courses are relevant, up to date, and have the standing and credibility of industry. Moreover, it reduces the cost of developing curriculum content for an area that has changed and expanded rapidly in just a few years. This makes teaching cloud services particularly challenging for that reason.

This paper outlines the AWS Academy programme and analyses its use and impact on one tertiary institution in New Zealand: Ara Institute of Canterbury (referred to in this paper as simply “Ara”). It documents the experience of academic staff involved in the programme, with the purpose of informing the tertiary sector, particularly but not exclusively in New Zealand, as to the lessons learnt and the approach taken to AWS involvement. Moreover, it considers some of the broader philosophical and practical complexities of tertiary institutions making use of vendor curriculum content.

2. The AWS Programme for Tertiary Institutions

Like other vendors, AWS saw the benefits of partnering with tertiary institutions to help satisfy the demand for professionals with knowledge and skills of the cloud generally but perhaps more importantly, from their point of view, people who understand the AWS environment. Their approach with institutions has been to provide this through two channels of support for education: AWS Educate and AWS Academy.

AWS Educate is principally a community for educators, where AWS provides an infrastructure so that academics can share their own course material and ideas, and access student credits for learning in the AWS cloud. These student credits can be obtained after applying and meeting certain conditions. AWS Educate enables academic staff to access and use various cloud-based tools, view blogs, sign up for webinars, offer their students “learning modules” and other AWS resources all free of charge (AWS, 2021a). In New Zealand 29 organisations are signed up to AWS Educate (AWS, n.d.) and according to AWS (2021a), throughout the world some 2400 institutions, over 10,000 educators and hundreds of thousands of students use AWS Educate. This uptake is not entirely surprising, given that AWS Educate has few barriers to entry and is designed to be informal and fun.

AWS Academy, on the other hand, is modelled on other academy programmes, like the well-established and highly respected Cisco Networking Academy. AWS has developed and maintains several courses that tertiary institutions can deliver. These courses now staircase through three levels: Foundational, Associate and Professional. AWS Academy is a formal, structured programme, with a focus on quality. Teachers need to first gain instructor certification and courses are done in a prescribed order. As figure 1 shows, everyone requires the fundamental knowledge of the foundational level of Cloud Practitioner. Once this groundwork has been covered, students can then proceed to different specialisations: architect, operations and developer. There are also some specialties, including security, big data and machine learning.

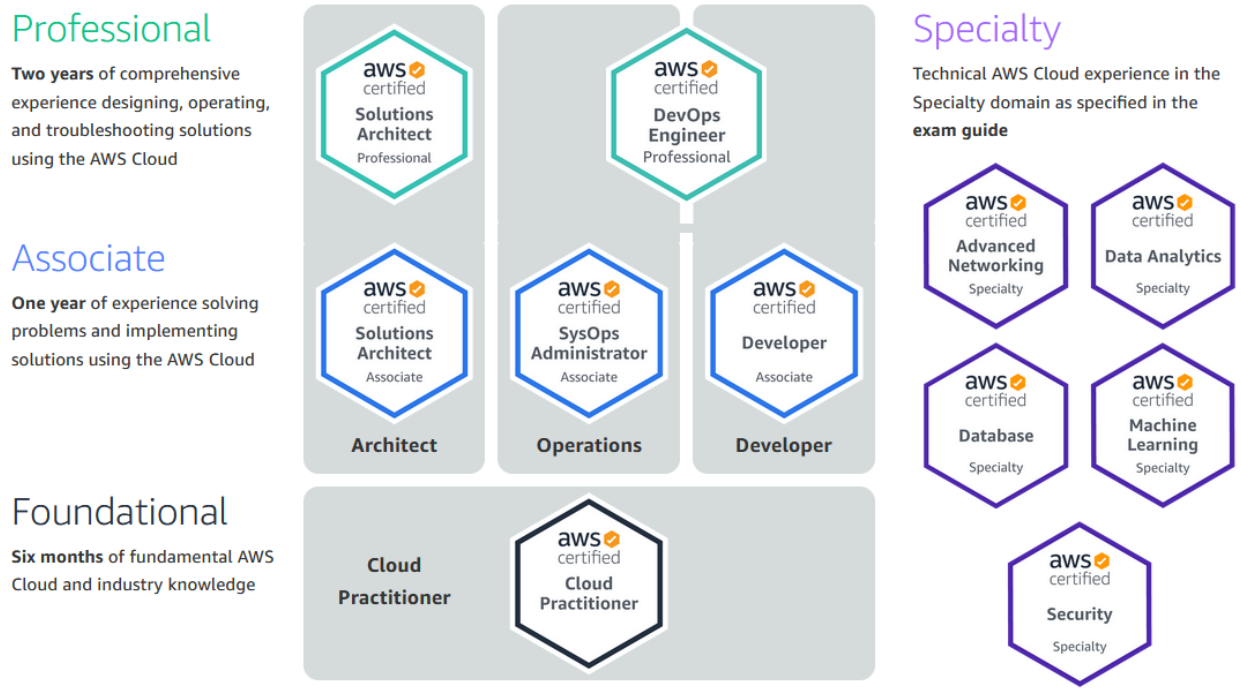

Figure 1: AWS certifications and courses (AWS, 2021b)

3. AWS and the Tertiary Institution

Ara Institute of Canterbury (Ara) (then Christchurch Polytechnic Institute of Technology) introduced a new degree level 7 course called Cloud Services in 2013. An academic staff member in the Department developed the course based on the AWS cloud platform. It introduced basic elements of cloud, specifically Infrastructure as a Service (IaaS), including virtualised compute (EC2), Virtual Private Cloud (VPC), subnets, routing tables, security groups, storage and databases, both relational and non-relational. The course even included hybrid networks using virtual private networks (VPNs) to connect cloud services to on-premise student virtual infrastructure. The labs for this course made use of the AWS cloud, as did project assessments (one called Greenfields and the other Brownfields). This custom content worked well and was refined, updated, maintained and delivered for several years (2013-2017) and the academic staff member involved in teaching the course maintained close ties with the (at that time small) AWS team based in New Zealand.

In 2018 Ara decided that it would move away from its successful locally written course. This decision was due to the constant stream of changes in methods of configuration, and ongoing introduction of new services on the AWS platform. This made it difficult to keep content up to date. Adopting AWS curriculum content seemed prudent, so the Department considered the efficacy of both the AWS Educate and the AWS Academy programmes. It discovered that AWS Educate, with its community focus, was a collection of resources of variable quality. Moreover, available Educate Classrooms did not have all the functionality needed for the course, for example, the need to include support for VPN encrypted tunnels to achieve hybrid network.

The decision was made to adopt the AWS Academy, since the courses are of a high quality and academic staff would no longer need to update course content, especially advantageous in view of the high number of changes to the cloud platform and tools for interacting with the AWS cloud environment. However, while it would free academic staff from the burden of updating and expanding curriculum content, it did mean that at least two Ara academic staff members needed to undergo training and gain instructor certification in certain AWS Academy courses. After five years of (mostly) teaching Infrastructure as a Service (IaaS) with locally developed content, it began delivering the AWS Academy Cloud Architecting course (ACA and ACAv2, version 2 of the course). The transition was not entirely smooth, and the introduction of AWS content, while beneficial generally, has complicated matters in some ways.

4. AWS Academy Content and Lab Environment

It soon became clear that adopting the AWS Academy into the Ara academic programme would likely lead to the use of multiple cloud related AWS courses, especially once AWS started staircasing their courses and linked them to AWS industry certifications. The AWS Academy programme accommodated the possibility of students gaining both knowledge and skills, across an ever-widening set of cloud services. As a result, the foundational AWS Cloud Practitioner course was incorporated as the second half of a level 6 course, and the associate level Solutions Architect is used as the level 7 Cloud Services course. Academic staff at Ara who teach software development are currently also considering adopting the associate AWS Developer course. Thus, AWS may increase its share of the Ara academic programme, but academic staff find these decisions difficult because of the implications of adopting other vendor-based courses.

AWS Academy courses incorporate lab exercises and associated lab environments. To the students, it appears as though the labs are hosted in the AWS Academy. When students start up access a lab, they select a link that then accesses a Vocareum lab environment, that makes use of a temporary AWS account and is hosted in the North Virginia region. Vocareum displays a split screen (figure 2). On the left is the document describing the lab, on the right it presents what looks like a command line shell or terminal. The students in fact use buttons at the top of the frame, one button says “Start lab” which initiates a temporary AWS student account and uses CloudFormation templates to automate the setting up of the required lab environment. The starting point of the lab is implemented in accordance with a lab topology diagram that the students are given. Then the students will select the “AWS” button at top of frame, to open an AWS Console environment window. The students can full screen this window, and it looks just like a normal private AWS Console environment.

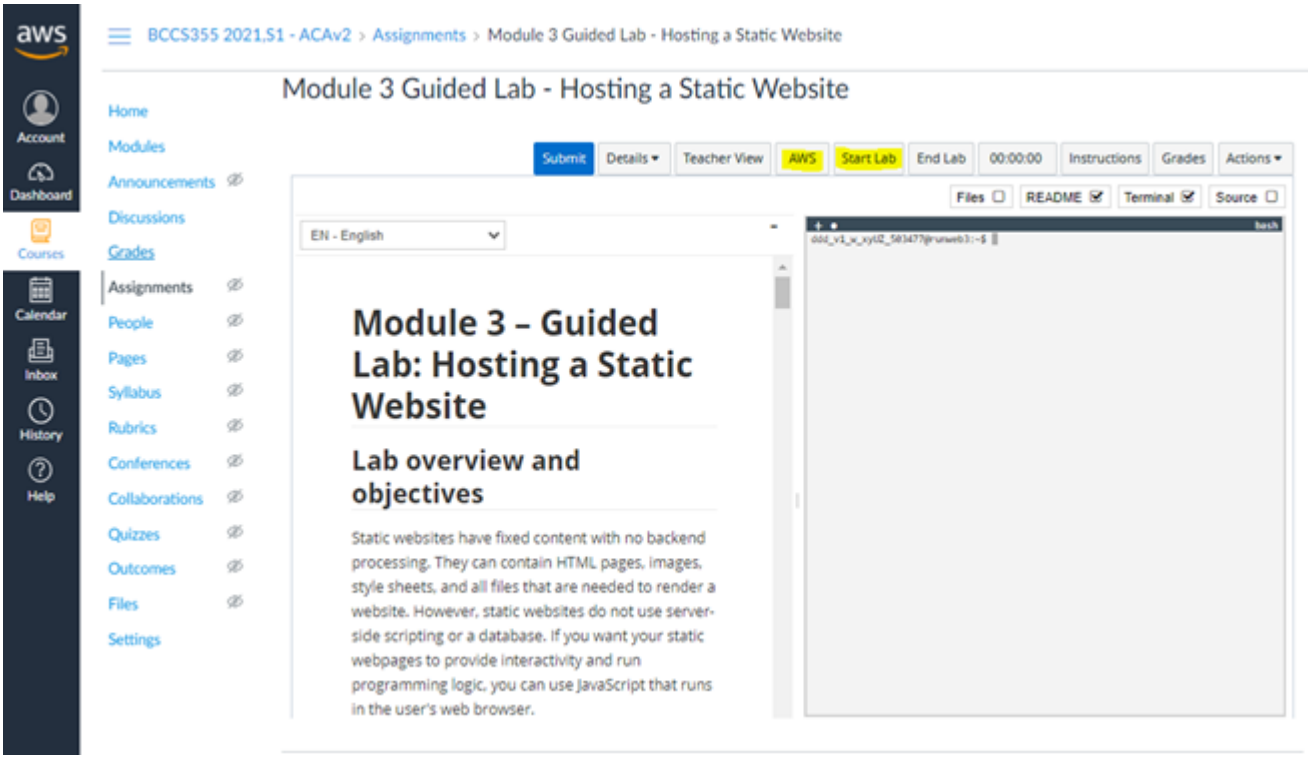

Figure 2: Vocareum lab environment

The ACAv2 course also introduced automatic marking of labs. Students can attempt the labs multiple times, but as this setting is not configurable by the teacher, it was decided to treat challenge labs as formative assessment. It was hoped that the AWS's course capstone project could be used as the main summative assessment, but this was also problematic. The AWS Academy hosted version of the project could not be customised, used auto-marking and was multi-attempt in approach. The solution in the end was to customise the capstone project and require it to be implemented in a student private account attached to AWS Organisations for credit distribution.

AWS Academy courses also offer a sandbox lab option. This sandbox is meant for experimentation and has an extendable countdown timer of four hours. The student only needs to hit the restart lab button and the timer restarts from four hours, while everything already deployed in the lab environment is retained. (The same occurs in the labs.) The restrictions and limitations of the sandbox environment make it difficult for students to complete Ara's own custom project set by academic staff (as opposed to AWS). Bringing up a successful VPN tunnel to achieve a hybrid network, along with all the other requirements of a Web/App Tier and Data Tier cloud solution, including importing a database dump file into the RDS Service, then backing that database up to an on-premises server, cannot be realistically achieved by a student within a four-hour sandbox. Even if a student extended the lab timer several times, working on the cloud capstone project all day, it was simply not possible for the typical student to complete all the requirements, within the available set time.

As a result, it is still necessary for students to open their own private account, and therefore apply for student promotional credits. These need to be obtained from AWS Educate (even though this is an AWS Academy course). It makes use of a centralised mechanism to distribute credit to private accounts that have joined the teacher's AWS Organizations account, as child accounts. That is, each student private account will need to join the teacher's AWS Organizations account. One enterprising student discovered that he was able to get an additional $300 of promotional credits by making a business case for it (AWS, 2021c).

5. Student Promotional Credits and Financial Risk

A key aspect of making it possible to access the AWS cloud is the system of promotional credits. Originally the teacher requested promotional credits for the class, and AWS issued individual codes for each student. Each student needed to open their own private AWS account (which did require students to make use of their own debit or credit card), and then attach the promotional credit that they were given. At first, this system worked well, but it was, at times, problematic. A few students would make a mistake or not pay attention to the resources they were consuming and accrue costs that exceeded their allocated student credit. When this happened, the teacher could not make the apology on students' behalf. Instead, AWS Academy expected students to raise their own AWS support service ticket based on their account, apologise for the overspend and request further credit. In every case AWS graciously reversed the charge.

This issue has occurred at other institutes in New Zealand and indeed other parts of the world, with one student reported to have been charged $200 doing an AWS tutorial (Brazeal, 2021). An evidently good solution would be to make use of a learner account model (Quinn, 2020). AWS understandably changed the way they enabled students to make use of their cloud platform. They stopped issuing promotional credits to individual students and instead if promotional credits were to be needed, they issued them in bulk and linked them to the teacher account. The teacher then needed to set up the AWS Organizations facility and student credits were distributed to child AWS Organizations accounts, under the teacher account. AWS also tried accommodating tertiary institutions by eliminating the need for student promotional credits altogether. AWS Educate make use of Educate Classroom environments, whereas AWS Academy courses take a different approach.

At Ara, the new AWS Organizations centralised credit system has posed some real challenges. In the second semester of 2020, several international students exceeded their allocated credit budget. They ignored instructions and did not stop, close or delete resources after completing their course project work, resulting in the teacher's private credit card being billed to the tune of NZ$602. Furthermore, not all students used private accounts, as they were given a choice and some students opted to instead use AWS Organizations child accounts that the teacher had opened. Therefore, when students abandoned these teacher-opened child accounts at the end of the course, without ending their use of cloud resources, the teacher had to do this on their behalf, so as not to continue to accrue further costs.

In the end the teacher had to raise an AWS support ticket, requesting credit to avoid having to pay all student use of the cloud. This credit was eventually received from AWS, after a wait of three or four weeks. Teachers usually do not have access to a credit card issued to their employer and Ara is no exception. In addition, some teachers may prefer to take on the financial risk than to have to explain the situation to their manager or employer. This poses a real dilemma, as to how best to handle student-incurred pay-as-you-go expenses, one that does not fit easily to the conventional way in which institutes of technology manage the cost of delivering a course.

In 2021, it was decided that students would not make use of the teacher opened child account option and instead open their own private accounts and then join the teacher's AWS Organizations account. This enables the teacher to disconnect student accounts from the AWS Organizations account, where they may exceed credit allocated. At that point, it becomes the student's responsibility. It is a matter of making clear to students that the typical spend will be mostly on their cloud capstone project solution. Effectively this is only US$50 per student. The teacher utilises Moodle to provide students with a summary of the costs of the cloud and guide students to use their credits wisely. Academic staff can reduce their exposure to financial risk since they can decouple student private accounts from AWS Organisations but students themselves can still face significant charges. Service Control Policies (SCP) also restrict child-accounts, but it does not remove the need to monitor for students who are not careful about their spend in the cloud.

6. Philosophical and Practical Considerations

Vendor curriculum content raises several challenges, some philosophical, others practical. First the philosophical. It raises the risk of a conflict of interest, be it actual, potential or perceived (Bryson, 2016). This conflict of interest can be defined as a "conflict between the public duty and private interest of a public official, in which the official's private-capacity interest could improperly influence the performance of their official duties and responsibilities" (OECD, 2005). It is critical that institutions adhere to some core principles in terms of managing the risk of corruption and such guidelines are readily available (OECD, 2005). For instance, the academic project should bear close public scrutiny and always serves the interests of the public in a fair, impartial way. It is one thing for academics to be committed to the truth, as is their duty as IT professionals (ITP, 2017), but it is important that they go beyond this and ensure that they retain a certain level of critical objectivity, both actual and perceived.

It could be argued that AWS and other vendors are motivated by self-interest, and their courses are therefore promotional and biased in a certain sense. It may raise the spectre that an industry player is able to unduly influence, even compromise student learning, that staff and students cannot be entirely critical of vendor technologies, that students are being trained not educated. This is a conflict of interest, but a conflict of interest is not in and of itself unethical, and sometimes difficult to avoid (Bryson, 2016). It does, though, need at the very least to be carefully managed, as the code of IT Professionals New Zealand (ITP) code of ethics suggests (ITP, 2017). Academics, at

the very least, need to mitigate this conflict of interest by bringing this to the attention of students (ITP, 2017).

Academics cannot avoid making use of one public cloud provider or another if they are to deliver courses on cloud services. Unless they only teach these technologies theoretically or severely restrict the practical experience by using local virtualisation or simulation, which presents its own technical challenges, students will experience a set of cloud services implemented by one vendor or another. This will come complete with that vendor's flavour of implementation and even resource product names. Still, academics do not have to make use of vendor courseware. They could use their own content, which imposes a major burden, not just in developing the initial content but also updating it. Another option is to make use of a vendor neutral source. Computing Technology Industry Association (CompTIA) is well established and well respected, but its focus has always been limited to the beginner, introductory level rather than more advanced aspects of information technology (CompTIA, 2021).

As figure 2 shows, AWS, like other vendors, has several courses in their portfolio. These cover different technologies and they staircase, so enjoy a certain unity and coherence. Unfortunately, one vendor promotes its content at the expense of another vendor. Ara uses a mix of Cisco and AWS content, but choices need to be made. These courses are obviously not designed to work together as part of a single programme. For example, both automation and cybersecurity appear in both Cisco and AWS courses, so which should be adopted? Should the Department make use of a Cisco course that contains Ansible, or should the Department use an AWS Academy Operations course that includes Opsworks, CloudFormation, AWS Systems Manager and other Puppet and Chef options?

7. Conclusion

AWS Academy course content achieves two major goals for tertiary institutions. Firstly, it offers a common unified (at least formal) curriculum that industry endorses and supports. Secondly, it promotes the consistency, uniformity and efficiencies that Te Pūkenga seeks to achieve. At the same time, as this paper shows, this is not a solution without its own risks and challenges, especially since it makes the delivery of courses dependent on the vendor, not just in terms of the theoretical content but also the associated cloud services and lab environment.

AWS has demonstrated a willingness to work with tertiary institutions. Ara has recently been active in providing feedback in the beta release of courses in cloud architecture. It means that academic must accept that some things may not work properly initially, for instance auto marking, and that they may need to improvise at times. Still, the Academy programme raises several vexing questions. For instance, how can teachers best monitor student use of the cloud reduce exposure to financial risk and how are teachers to respond if a student loses their work before gathering evidence of the work, they did in the lab environment? These questions multiply when more vendors partner with tertiary institutions.

The AWS Academy programme partnership reflects the tension between academic and vendor interests. The vendor acts in good faith and even incurs a substantial cost to support the partnership with tertiary institutions, but it does not, indeed cannot, adapt its courses to individual institutions' diploma and degree programmes. That is not its focus, even for Microsoft and Cisco, which have been providing courses for tertiary institutions for over 20 years now. On the other hand, AWS is, relatively speaking, a newcomer and therefore issues can be expected. Such partnership academy programmes are difficult and complex to implement due to not just the vendor making its services accessible to a wide range of people but also its global reach and everything that that entails.

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Power Supply Dynamics for Outdoor IoT Sensors in New Zealand

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Abstract

The paper documents the authors' power usage experience and hardware related designs, and concludes with a summary of the leading options available, with indications of the factors to be considered in choosing the options to use for a particular situation.

The authors are committed to open standards-based, accessible, and affordable environmental monitoring, as part of national initiatives to restore biodiversity and plan for climate change.

Research is presented using an Iterative Action Research model. Using a formal model allows the authors to highlight the common themes in their research while contextualising differences in the way they approach a common challenge.

Power requirements are critical to a successful IoT deployment in any environment which doesn't have a continuous power grid available. Following the guidelines presented in this paper will enable a sound platform for building a successful IoT environment.

Keywords

Power Consumption, Internet of Things (IoT), Solar, Open Source, Iterative Action Research

1. Introduction

The term 'Internet of Things' (IoT) describes a growing network of Internet connected devices of various types, used in all areas of 21st century life. Many of these devices are sensors, predominantly commercial products that are used by the million, in situations like car parking or street lighting (IEC, 2016).

This paper considers power requirements of those sensors that are in challenging situations in New Zealand. In particular, they might be in locations that are special by

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In this section we introduce the conservation environment of New Zealand, to show the place of this paper within the broader picture.

1.1 Structure of Organisations in Conservation

Reports in the media and relevant websites suggests New Zealanders are becoming increasingly engaged in conservation. Craig et al. (2013) conducted an early analysis which was widely reported in various fora. This section cites a number of organisations that have been established since 2013.

It is a very complex domain. There are numerous organisations involved with various inter-relationships. The authors find it useful to use a triangle model to describe different views of these inter-relationships. The metaphor of using the mechanical strength of the triangle to describe many aspects of human society is eloquently expressed by Kim et al. (2001).

The most significant driver of New Zealand conservation is removal of predators. Towns et al. (2001) show how one range of native creatures (reptiles) can thrive when introduced predator numbers are reduced. They looked at the end of the 20th century. Twenty years later this strategy has caught the imagination of the population, significantly boosted by a Government-led campaign with the stated aim to remove all introduced predators by the year 2050. The Predator Free NZ Trust (PFNZ) lists over twenty 'key players' (https://predatorfreenz.org/big-picture/pf-2050-vision/). Many of these groups have thousands of members.

One way of viewing the 'Big Picture' would be a triangle consisting of three interrelated drivers:

- **Funding:** Dominated by Government body Predator Free 2050 Limited (PF2050) and the private NEXT Foundation, along with thousands of smaller players contributing money, capital and labour. (https://pf2050.co.nz/ https://www.nextfoundation.org.nz/)
- **Community Efforts and Knowledge:** Organisation supported by PFNZ, including Iwi, community groups, landowners and others, many identified in the

PFNZ link above. One of the current authors – Andrew Hornblow – is represented here.

- **The Research – Technology – Product cycle:** Some large organisations active here include Zero Invasive Predators (ZIP), Department of Conservation and Operational Solutions for Primary Industries (OSPRI) (https://zip.org.nz/ https://www.doc.govt.nz/ https://www.ospri.co.nz/about-us/). The education sector has a key role, and there are private companies contributing in various ways. Two authors, from Econode, are in this area (https://www.econode.nz/aboutus).

These three drivers support each other in a virtuous cycle. The Community has been undertaking conservation work that can be traced to the 19th century (https://www.forestandbird.org.nz/about-us/our-history). That long-term background has contributed to a country that creates and encourages funders. With funding, the Research community can create new products which extend what the community can do, and cycle continues.

1.1 The need for sensors

The community driver outlined above has achieved significant results over the past hundred years using very effective devices created from simple 'seat of your pants' technology and knowledge. Grant Ryan of the Cacophony Project (https://cacophony.org.nz/) makes a case that Information Technology could improve the efficacy of predator control by a factor of 80,000 times (TEDx Talks, 2016).

There have already been significant examples of regeneration and recovery of native flora and fauna through the work of Predator Free 2050 Limited (PF2050, 2020). Sensors are important in both the predator removal process and monitoring of species recovery. One of the early documented accounts of sensor use in the type of environment considered in this paper is ZIP (https://zip.org.nz/). This organisation contributed to development of the concept of a 'virtual fence' and documented progress, including the use of sensors, in their inaugural 'annual' report (*ZIP Report to 30 June 2015*, 2015)

1.2 The place of Electric Power Dynamics in Conservation

An analysis and prediction of '*Number of Internet of Things (IoT) connected devices worldwide from 2019 to 2030, by vertical*' asserts there were about 7.8 billion devices in 2020, which is predicted to increase to about 22 billion by 2030 (Transforma Insights, 2020). The vertical market '*Agriculture, Forestry & Fishing*' is the closest fit to conservation. This market is predicted to grow to about 20 times its current size. This is a predicted growth rate averaging seven times the growth rate of other markets.

The authors believe that sensors will proliferate among those 22 billion devices, however conservation will have the greatest reliance on use of sensors which lack an established power source.

A case can be made that power dynamics for low-power sensors will be a significant influence on conservation work over the ten years. Our analysis of the literature

suggests this is an area that is currently underreported. The underlying electrical principals date back to the 19th century. Some older literature such as Belhadj-Yahya (2010) can inform modern usage, but the way that electricity is generated and used continues to improve at a great rate. Battery selection can be informed by publically available datasets such as dos Reis et al. (2021), but battery technology is just one part of the power dynamic question. This paper will consider a broad range of options, informed by the authors' experiences.

We suggest that makers of products supporting New Zealand predator eradication can be modelled on a matrix of two axes:

- **Commercial Imperative** represents the degree to which the product producer needs to make a monetary profit or surplus.
  This will clearly affect the investment choices. A producer without a strong commercial imperative might have access to non-monetary resources, particularly labour.
- **Design Kaupapa** represents the approach the producer has to making design elements available to the community.
  There is a long history in the literature documenting the benefits of open sourcing of product intellectual property, particularly to those without financial resources (Lerner & Tirole, 2005; Watanabe, 2001). Grant Ryan – Cacophony Project initiator and coordinator, articulates this position well (TEDx Talks, 2016). There could be value in more organisations being placed appropriately on Figure 1 A Matrix of Design & Commercial Dimensions. The example below has the authors' products positioned on the matrix for further reference in this paper.
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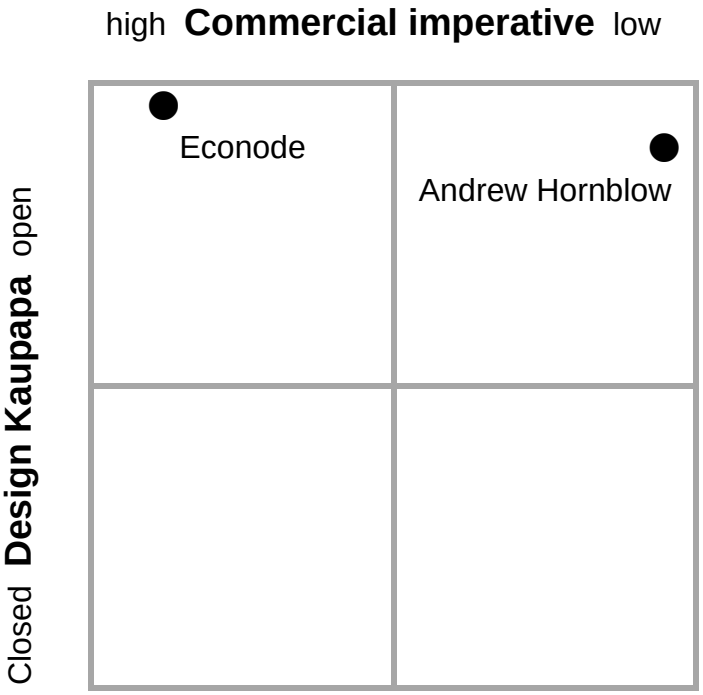

Figure 1 A Matrix of Design & Commercial Dimensions

1.3 Structure of this paper

This paper starts with an introduction to the subject matter. This includes a context-setting description of the New Zealand conservation industry and the place of electric power dynamics in sensor networks.

The academic research method is described, including how the authors see it applied in the context of the subject at hand.

Three subsequent sections describe the options available and how each of the authors apply those options in their work. Application is described in terms of the previously defined research method.

Finally the paper concludes with suggestions for further research and a summary of how the authors see the academic community making a strong contribution to the future of New Zealand biodiversity.

2. Aims and Research Design

This paper will contribute to the readers' understanding of parameters of the New Zealand conservation sector. That understanding will inform identification of a set of parameters to use when provisioning power to sensor deployments in an efficient and effective manner. The result will include open-source design guidelines that the research community can implement and further analyse for the greater good (Lerner & Tirole, 2005).

We will answer the question: "How can the most effective power supply solution be determined for a sensor in any specified environment?"

The literature shows solutions that were applicable in the 20th and early 21st century (Belhadj-Yahya, 2010). In the past ten years all technologies in this field have been significantly improved and optimized, while prices have fallen. This project builds on previous work to develop new designs using current and emerging technologies specifically intended for power-challenging situations in New Zealand. The authors will then implement and analyse the outcomes to create a source of current information.

2.1 Research Method

The research uses an iterative action research method to build this contribution to the wireless sensor literature. This concept of adding iteration to an active research model was introduced by Susman & Evered (1978). The authors have reduced Susman & Evered's five phases to four as shown in Figure 2. The iterative approach to action research was well articulated and supported by Kock et al. (1997).

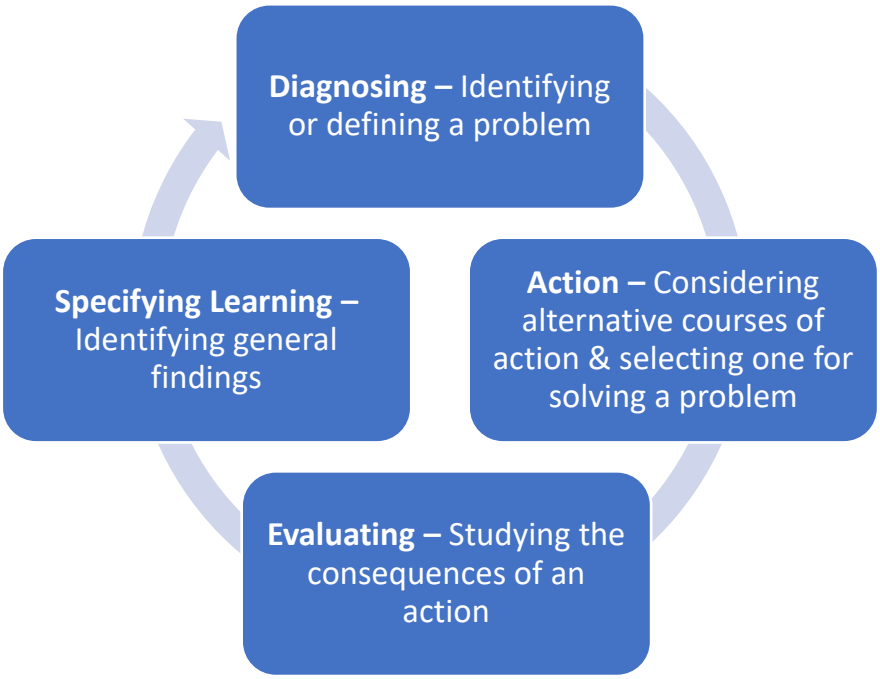

Figure 2 A cyclical process of action research adapted from (Susman & Evered, 1978)

These phases very closely map the way the authors of this paper structure their work:

- **Diagnosing –** This paper has established a very broad picture in section 1 above. The detail of problem definition within that broad picture is based on various criteria discussed in this paper.
- **Action –** The authors have extensive experience in their domain. They are able to take the problem, identify and evaluate potential solutions, then construct an artefact that is expected to solve the problem. (Combines Susman & Evered's 'Action Planning' and 'Action Taking' phases.)
- **Evaluating –** Studying the consequences of implementation of the artefact.
- **Specifying Learning –** It is essential that consequences are evaluated and articulated in an appropriate form to continue the cycle of diagnosis and a new iteration.

2.2 Applying Iterative Action Research

Collectively, the authors have experience across many sectors of the IoT community. This includes: commercial sensor deployment across a broad range of remote and urban environments; controlled and open field experiments; desk-based analysis; all using a wide range of sensor hardware characteristics. Over several years those characteristics have been modified for each application and to accommodate the needs of each location. This research design has resulted in successive iterations in the evolution of sensor power supplies.

Our non-commercial author, Andrew, started his work in this area by defining a very general problem – School children are not being sufficiently engaged in science.

Hipkins (2009) is one of many authors who have articulated various aspects of this problem. This paper considers Andrew's research with power dynamics for IoT sensors. In that context, he has implemented the Action Research process relying on his own resources which are strongly electronics and hardware focused. His diagnosis of the power problem, and planning to act on that diagnosis generally relies on his own experience. The action phase tends to focus on smarter use of currently available resources.

Econode has been built around developing open and commercial solutions to a particular big challenge – The New Zealand Pest Problem (Way & Way, n.d.). Within that challenge they diagnose the current state of the industry to identify a particular problem. That problem can come from any stage of the product life cycle. For Econode, the action phase requires consideration of a very broad range of options. Appropriate technologies are acquired or developed which are used to develop a solution to a particular problem, while being mindful of the interaction of that solution with the entire Econode infrastructure.

The authors suggest that it is in the evaluation and specification of learning phases that their different kaupapa results in quite different needs and actions.

After introducing a new solution, Andrew gathers his own observations together with those of his research collaborators, informed by real-time data using the Cayenne (n.d.) IoT visualisation platform (http://bit.ly/Penguins2021). He then discusses these observations with his collaborators, with the help of annotated diagrams such as Figure 3 Example of Annotated Penguin Sensor Data. The evaluating phase uses this data to identify the consequences from each iteration. Things learned from the iteration are then used to identify another problem to work on. The action research cycle then continues.

For problems in the context of power dynamics, Andrew has identified that the most effective action he can take is often reducing the number of parts, or finding ways to reduce the power consumption of the parts being used. This is consistent with the observation above that Andrew relies to an extent on using his own electronics and hardware resources. On the other hand, when an appropriate new technology becomes available, the non-commercial product development model gives Andrew agility to be able to take advantage of that technology quickly. Such an agile model requires participation from all stakeholders. While this works for many partners, largely in the conservation and school sectors, other people in these sectors prefer to work with a science partner who has a different business model. This results in Andrew's observation "Making things simply using the least parts and energy makes no-one famous or rich."

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Figure 3 Example of Annotated Penguin Sensor Data

Econode conducts the 'Evaluating' phase thorough evaluating, feedback and specific learning from a broad range of projects. Each solution has been targeted at a particular predator free project. They evaluate what's working and what should be improved. This is informed by input from contractors who install their products in the field, and by monitoring the product's performance, which is assessed during each cycle. After identifying what has been learned, new problems can be identified, and the cycle continues.

This process has enabled Econode to enhance the product's performance by taking advantage of the current availability of technology in the market. When they started using LoRaWan and IoT technology in 2015, there were not many support devices available. They had to build their own complete solution. Now there are many options in the market and development can focus on the flagship product, the SmartTrap. This process has enabled Econode to add significant improvement in both design and functions to each generation of SmartTrap nodes.

3. Options for Power in Isolated Locations

Having previously defined the scope of this paper, this section describes various power supply paradigms and devices, then considers problems and some solutions. Finally longer-term issues are described. The following section describes some case studies using the options discussed here.

There is a very wide range of options being developed which challenge long-held views of how power can be provisioned.

Note that while technically a battery has been defined as a group of two or more cells that furnish electric current, common usage sees the term also used to describe a single cell (Merriam Webster, n.d.). This paper will use the term 'battery' to refer to one or more cells.

3.1 Power Storage

Batteries have been used for remote power supplies since the 19th century (Whittingham, 2012). The authors see this continuing, however the batteries continue to change. At a basic level, a battery is described in terms of the two metals (an anode and a cathode) that are the active components. Since 1991, the anode in most rechargeable batteries has been Lithium. A variety of metals have been used as the cathode, and alternatives to Lithium are also being developed. It seems likely that different applications will better suit one battery technology over another (Placke et al., 2017) into the foreseeable future.

The authors divide sensor battery needs into two major categories: Primary batteries are those used for small sensor devices, generally using a very low power 'System On a Chip' (SoC); Secondary batteries power infrastructure devices that have higher power requirements.

Three factors are converging to lower the cost of primary batteries: devices are using less power – now measured in a decreasing number of microamps (µAmps): battery performance is improving, both the active capacity of the battery and the expected shelf life; prices are dropping. The authors consider Lithium-Thionyl (Li-Socl2) as the highest-performing option for a primary battery. Unfortunately, they are also very expensive, in the order of $20 for one AA cell. On the other hand AA alkaline batteries are cheap, simple, and reliable. The authors have used Eclipse AA batteries 40 of which can be purchased for under $15 (Jaycar, n.d.). These can be relied on to have a shelf life of five years and active capacity to power a simple sensor for that time.

Sensors designs now allow for very low power demand, which means less power is required to run them. Single use primary batteries should power a sensor for many years.

Secondary batteries need to be very carefully considered. These power a very wide range of devices, typically measured in hundreds of milliamps – orders of magnitude more that primary devices.

The authors have found that Li-Socl2 batteries are significantly more reliable. They have excellent shelf live and retain full capacity for longer than other chemistries. This needs to be weighed against the high price. Another option that has been found to be a reliable secondary power is a lithium-ion polymer battery (LiPo).

Another power storage option is a Super-Capacitor. These can be compared with a rechargeable battery but are capable of a virtually infinite recharge cycle. Whittingham (2012) describes uses for these in situations where there is a significant amount of space to hold the capacitor. The authors agree with Whittingham that these will be considered alongside batteries at some point in the future. The technology is not yet suitable for small, portable, applications.

Considering these notes in the context of Figure 1 A Matrix of Design & Commercial Dimensions, while the authors agree on the characteristics of power storage technologies, their individual dimensions result in different choices.

Econode are developing commercial solutions for sites that can be very expensive to access. For primary storage, their designs currently use easily replaceable batteries that can be relied on for five years or more. Often AA size Alkaline batteries are sufficient here. In some circumstances the long life of Li-Socl2 will be worth the significant extra cost. Secondary storage tends to high quality PV panels with non-replaceable rechargeable batteries appropriate to the site. Econode is developing new technologies with ever decreasing power usage. As relay and gateway (secondary) devices get more efficient, they might also move to primary battery types.

Andrew's costs are not always easily recovered, and his client base is more diverse. His activities can start with a pre-school child, a button battery and LED light, through to a device to read and remotely report the Radio Frequency IDentification (RFID) tag on a passing penguin (Mattern & Seed, 2020, p. 17). This leads to a very wide range of power storage choices, ranging from AA alkaline batteries on devices used for demonstration and short-term/low current projects, while generally using a 'happy mix' of any PV panel matched with a permanent LiPo battery on medium to long term projects.

3.2 Power harvesting

We established in section 3.1 above that the authors have a need to recharge batteries for secondary power requirements. In the context of this paper, a harvesting solution must be able to generate energy in isolated locations.

Secondary power is typically required by a wireless repeater, which often picks up signals from a sensor (running on primary, non-rechargeable power for multiple years) and repeats that signal so the signal can be received by a gateway device which will transfer the signal to a suitable cloud provider. Repeaters can also be configured to repeat signals from each other. The gateway device does, itself, consume secondary power, at a higher rate than a repeater.

Solar photovoltaic (PV) panels are very commonly used to charge the secondary battery discussed in section 3.1 above. Modern monocrystalline PV cells have made panels smaller and more efficient (in the order of 15-20%) than polycrystalline ones previously used extensively (13-16%). Econode has observed this gain in PV efficiency, coupled with reduced power usage and more efficient power monitoring and management (results from the iterative research process). The process lead to Econode having a design goal to create a versatile repeater with smaller physical size meaning less weight and wind load. This is described in section 5.2. Another important component of the Econode design is to have the batteries and electronics directly under the solar panel, so the panel forms a roof.

An air gap between the solar panel and electronic casing will provide cooling for the batteries, lithium batteries don't handle heat well.

Vibrations contain energy. Research in this field tends to be concentrated on opportunities to harvest energy created by the movement of motor vehicles. Okkeh et al. (2018) suggest that street design can service this purpose. Vehicle drivers would likely agree with Wang et al. (2016) that there is a significant energy exchange when a vehicle goes over a speed bump. None of the literature found, or experience of the authors, has suggested a solution for energy harvesting from vibration in remote areas yet, however it is a developing field.

The remote areas of New Zealand often have significant qualities of wind and water. These are both excellent sources of energy. The experience of the authors, however, suggests there are significant problems with harvesting this energy for very small scale projects.

The reason for sensors being in remote areas is generally associated with retention of the natural environment. Robust and sustainable water-based electricity generation tends to conflict with that objective. Less invasive methods tend to be prone to failure when subjected to natural threats such as flood.

Wind harvesting has been used to generate electricity in various situation for many years. Once again, in the locations being targeted by this paper, the traditional wind turbine is often too bulky or intrusive to be a viable solution. Rotating blades also introduce the hazard of bird-strike (Straka et al., 2020). This risk is unacceptable where there are vulnerable bird species present. One wind technology that has some potential is piezoelectric electricity generation. This process is well described by Wang et al. (2019). They did not, however, use the electricity generated to power sensitive electronic circuits of the type commonly use it in a sensor infrastructure.

There are a number of other options being researched or used in limited areas. An example is Wang et al. (2019), mentioned in the previous paragraph. Other harvesting techniques, “both well-known and novel”, are explored by Curry and Harris (2019). One potential future energy source they mention is generating electricity from biological sources. This research area is further developed by Ayala-Ruiz et al. (2019). Similarly, Elahi et al. (2020) review “energy harvesters based on mechanical, aeroelastic, wind, solar, radiofrequency, and pyroelectric mechanisms”.

3.3 Common Issues for PV Panels

The most obvious question when considering power dynamics for sensors is current draw of each device being used. This is an area where the authors take different steps to achieve the same outcome, as described in section 2.2. Andrew works on achieving savings through clever use of software and different components that can result in power consumption savings. Econode use a more data-intensive approach to monitor device performance, and aggressively research new technologies for savings.

Specifications for a particular application need to be carefully thought through and planned. A person requesting a sensor may not understand that a remote radio data link can easily account for 90% or more of energy requirements. Simplifying the data

collection cycle by reducing the number of readings can make a significant difference to overall energy consumption. An example Andrew has found is that ambient temperature only needs a once in 10 minutes duty cycle and rounding the value being transmitted can save much radio data. 'Smart' pre-processing is essential. Smart choice of what works saves cost and complexity.

The most commonly used energy harvesting techniques listed in section 3.2, wind, water and sun, each have issues identified in that section. The common factor is a need to alter the environment to accommodate each technology. In the context of this paper, the solar photovoltaic (PV) panel is the significant device for provision of electricity.

While the research process generates new solutions, traditional PV panels will remain in widespread use. These can be very site specific if they need to supply a significant, consistent power. Where there is a good understanding of the power requirements, Andrew has found that a lithium-ion polymer battery (LiPo) battery and suitable size PV panel can be a simple and effective solution.

The biggest challenge is external material that prevents sun getting to the panel. Some of the common examples in conservation work are:

- Guano from animals, birds, reptiles and insects.
- Dust, dirt and leaves blown or fallen on to the panel.
- Growth of plants around the panel (for medium to long-term installation).
- Overhead canopy of trees shading the sensor. This might not be obvious during installation. The sensor in Figure 4, with a small PV inside the case appears to be in clear space but delivered poor results for most of the day. The same sensor worked flawlessly when in clear sun. The larger PV shown at the same location in Figure 5 worked well.
- Disturbance by passing creatures. Generally this can be predicted, and the PV panel secured to mitigate this risk. An unexpected disturbance is shown in Figure 6, where it appears a passing Little Spotted Kiwi sensed insects or invertebrates moving under the sensor and tipped it over so it could eat them.

3.4 Resilience and Digital Twin

Econode is integrating the concept of digital twin in new developments. The term can be defined as "a virtual representation of a physical asset enabled through data and simulators for real-time prediction, optimization, monitoring, controlling, and improved decision making." (Rasheed et al., 2020).

This will be achieved by inclusion of a high precision volt and current meter (+/- 2mv), so Econode will be able to get a lot of statistical data about the panel performance. This is being achieved by using two INA226 modules (https://www.ti.com/product/INA226), one on the solar panel, and a second one on the batteries. Along with regular sensor data, these power statistics will be sent to the IoT cloud provider.

The purpose of the Digital Twin is to monitor the device under test over its operational life time. One outcome could be should foliage grow over the solar panel, or a solar panel gets bumped or knocked, this will show as an anomaly and action taken. As the Digital Twin is informed by monitoring, environmental changes over time can be predicted, and combined with estimated run time on the internal batteries.

Figure 4 Sensor with small PV at ZEALANDIA

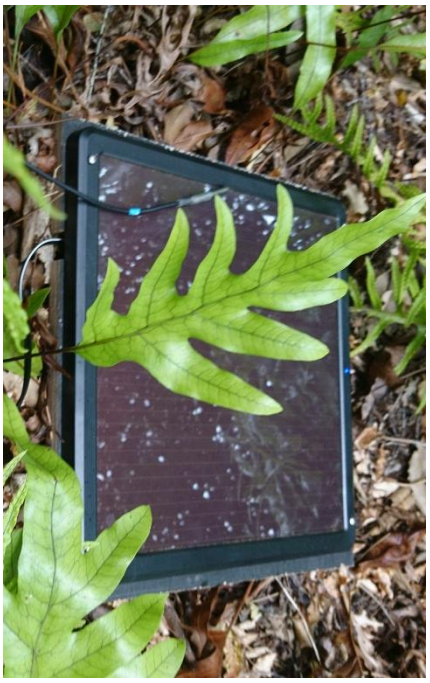

Figure 5 Sensor with large PV at ZEALANDIA

Figure 6 Sensor tipped over by a Kiwi in ZEALANDIA

4. Case Study – Andrew Hornblow

The authors' approach to iterative active research was outlined in Section 2. Aims and Research Design. This section summaries some examples of the work of one author, showing how he applies the research design process

4.1 Taranaki Penguins

Andrew's longest-running project has been thermal detection of Penguin nest box occupation around the Taranaki coastline (Figure 7). Initially these used simple data logging devices which needed to be manually read periodically. The iterative research process saw the development of sensors with a remote wireless link to a locally hosted IoT backend of the time.

For the first five years three AA alkaline batteries would last a breeding season of about 6 months. Battery life decreased as more data was being transferred. A recent development is use of 250mAh LiPO batteries charged by a small solar PV. The evaluation phases of this change established that excess charge is extremely unlikely to be an issue. Power is managed by balancing load to state of LiPO charge. When there are sustained periods of sunshine, the transmitters are left running for longer to avoid overcharging.

4.2 Schools Digital Curriculum

During the years 2016 – 2018, The New Zealand Ministry of Education (MinEdu) ran a pilot Digital Technology learning unit. As part of that, Andrew contributed to a project where students built data loggers based around an educational microprocessor, the PICAXE 08M2 (Revolution, 2021).

Students built a device to monitor a range of environmental and building metrics. Those metrics included soil dampness, water table levels, dwelling temperature, bedroom timber moisture and temperatures. The program was very short but the simplicity of single processor and 3 AA Alkaline batteries, thermistor or nail moisture probes meant a that the cost to a school was less than $10 per student. This could be expanded by the addition of a basic Message Queuing Telemetry Transport (MQTT) broker that connected these to a free IoT cloud service (Cayenne, n.d.) using the MQTT TCP/IP protocol. The broker ran on a Raspberry Pi computer on the school Local Area Network (LAN). Andrew asserts that MinEdu took some interest in the building timber moisture testing possibilities!

One secondary school developed this theme, and engaged with Andrew to produce a significant 'IoT Course' which enabled students to work on unit standards in three parts of the Digital Curriculum (Wanaka Sun, 2017, p. 7).

- Students completed an electronics unit while assembling the sensors.
- Programming the sensor completed a Computer Programming unit.
- Creating a 'dashboard' to display results completed a web page development unit.

Figure 7 Penguin nest boxes near the Port of Taranaki

4.3 Taranaki Sound Lures

Primary aged students at Auroa School in South Taranaki identified that the whio duck was endangered by predation from stoats in the streams on their farms. They worked with Predator Free Taranaki (https://predatorfreenz.org/5126-2/) and local existing farmer pest control groups. They were supported with electronics support from Andrew, education guidance from the school deputy principal and conservation support from the local Rotokare Sanctuary and the Department of Conservation.

The project generated considerable interest. Students and the school have been acknowledged by the South Taranaki Regional Council and the annual Tahi Rua Toru Tech! national school technology competition (https://123tech.nz/) where they won their grade in 2020 (Groenestein, 2021).

The project required assembling and programming a PICAXE-based circuit that included a module holding an MP3 player and 3 Watt audio player. The code developed by these students selected a sound track that could attract the target species while manipulating volume and using solar load management for optimum battery life (Taranaki Mounga, 2020). In May 2021 the first unit of this design to be deployed was retrieved for maintenance. After two years literally 'in the field' running with a medium sized PV panel and a 2000mAh LiPO battery, it was found to be working well, just needing the replacement of some rusty terminal screws and bolts. Andrew sees this project as an example of the success of the iterative action research cycle. The next problem identified has been lack of feedback from this device. The project team aim to use a full-

duplex LoRA connection to their IoT cloud to control experiments in real time. Understanding the enemy and closing the loop on what works!

5. Case Study – Econode

It was made clear in Section 2 that the authors who create products apply the iterative action research methodology in different ways. Here the Econode authors outline an example of their data-centric approach to the research design process.

5.1 Battery Use in Econode nodes

Software developed by Econode records a range of telemetry data from each node, some of which is shown in Figure 8. This enables monitoring and analysis of the node operation.

This was used in the 'Gen5' nodes deployed in November 2019 for Predator Free Taranaki. Each node is powered by four consumer-grade alkaline batteries (Jaycar, n.d.). At the time of writing, the highest price for these batteries was about 42 cents each, or $1.70 for a set of 4. This is an example of the Econode kaupapa of keeping costs down contrasts with another sensor supplier who list a replacement battery pack, with a comparable duty timeframe, for $50 (http://bit.ly/OutPostInfo).

Firmware used in the Gen5 nodes used in this trial require 3.3 volts. They use 4 µA in sleep and about 70 mA when transmitting. Each two hourly transmission takes about 2 seconds. Battery voltage decline is shown Table 1 Actual power consumption Gen5Rev3 SmartTrap nodes PF2050 Taranaki. An example of an Econode circuit board is provided in Figure 9.

Table 1 Actual power consumption Gen5Rev3 SmartTrap nodes PF2050 Taranaki

4 x AA alkaline batteries

Date: / **Node**	2019-11	2019-12	2020-01	2020-02	2020-03	2020-04	2020-05	2020-06	2020-07	2020-08	2020-09	2020-10	2020-11	2020-12	2021-01	2021-02	2021-03	2021-04	2021-05
4023	6.33	6.26	6.23	6.11	6.07	6.05	6.04	6.01	6	5.99	5.95	5.94	5.84	5.82	5.81	5.75	5.53	5.48	5.46
4029	6.25	6.24	6.22	6.2	6.06	5.95	5.84	5.77	5.72	5.71	5.66	5.67	5.64	5.63	5.6	5.59	5.57	5.52	5.47
4030	6.5	6.42	6.22	6.12	5.99	5.93	5.9	5.87	5.8	5.78	5.77	5.77	5.77	5.76	5.75	5.74	5.75	5.74	5.74

These figures suggest that about two and a half years battery life is achievable. Econode estimates that standard lithium batteries would power a node for about five years with a price of about $20 for a pack of four. It is likely that a pack of lithium-thionyl chloride batteries would have double the lifetime – about ten years.

5.2 Secondary Battery use in Econode Infrastructure

As described in section 3.1, the authors distinguish primary battery needs (as described in the previous section) and secondary battery needs, for infrastructure components that have a higher current drain. This section introduces power needs for LoRaWAN radio gateways and repeaters.

A gateway is required to run its radio 24 hours a day, to receive any signal that needs to be uploaded to an IoT Cloud. This will typically require a current of about 300mA at 12 volts. The current research and implementation phase of this infrastructure requires a typically large 200 watt PV panel, with associated heavy 12 volt deep cycle lead-acid battery.

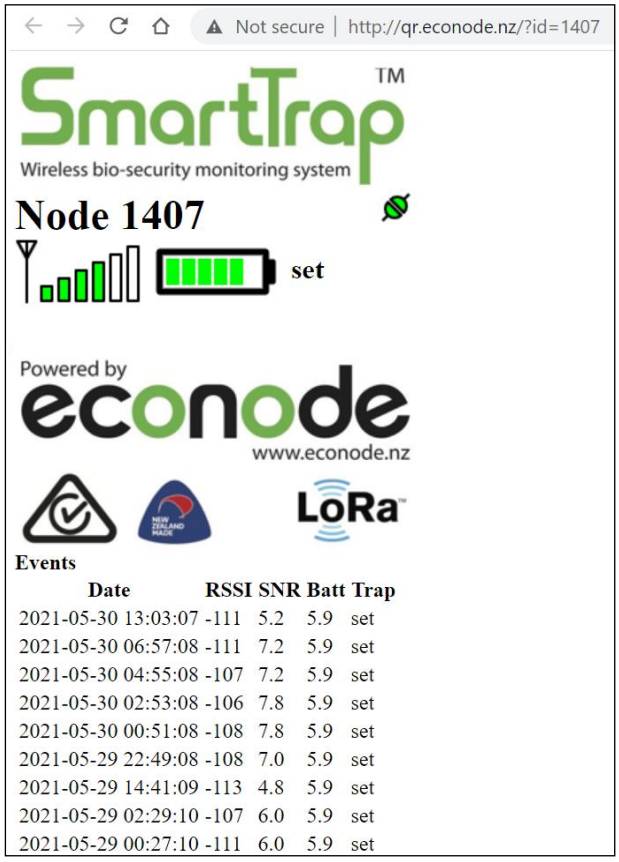

Figure 8 Example output from one node

Figure 9 Example of a SmartTrap Node Circuit Board

Repeaters are used to pick up the signal from a node then transmit it to a gateway within range, or another repeater.

Econode is developing an 'IoT Power Board'. This will allow maximum efficiency, flexibility, reliability and monitoring capability to support improved power management in future designs. One of these boards is shown in Figure 10 Example of an Econode Power Board. This is a circuit board that will be mounted in the same case as a sensor node and will manage and monitor power from a variety of sources in a very efficient package.

Econode intends to make this available as an open source building block to other makers both commercial and non-commercial or maker space.

There is a significant amount of complexity with the IoT power board most of which is about making the device safe and robust.

- Each battery is interdependently monitored for thermal run away.
- Over voltage / Over current / Under voltage protection is included.
- Reverse battery or solar panel polarity will be detected.
- Over / Under temperature charge will lead to cut out.
- Moisture ingress will be monitored and notified.
- Power path options will be monitored as optimized as configured.

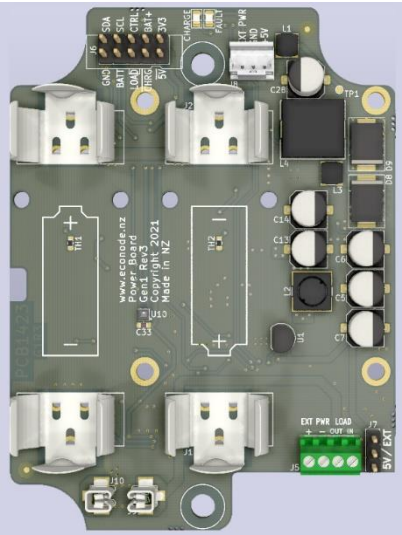

Figure 10 Example of an Econode Power Board

Action on the currently identified gateway, repeater and secondary power problem is focused on building a 'mini-gateway'. This device will use 3.3 volts, continuously drawing about 20 mA while listening for signals from nodes. When repeating a signal to a gateway or another mini-gateway it will use about 70 mA. When it is required to use a 4G cellular network to transmit data (in the absence of a gateway device), it will use about 120 mA for a short period of time.

These power requirements will fall between those of a node and a gateway. The mini-gateway will require rechargeable batteries and solar panels, however Econode is confident that it will weigh under 1.5 Kg, including batteries, solar panel, case, mounting brackets and any other required parts. This allows for relatively easy field deployment compared the requirements for a conventional gateway described earlier in this section.

6. Further Research & Conclusion

This paper has described the operating context in which most outdoor IoT sensors operate in isolated parts of New Zealand. The authors then described their own experiences, using an Iterative Action Research model. This final section will suggest some additional areas of study and conclude with a view on the place of outdoor IoT sensors in the future.

6.1 Further Research

This paper has used literature from many sources, each approaching sensor network power requirements in a different way in order to address questions relevant to their specific requirements. Few peer reviewed publications come from New Zealand despite there being a clear need and enthusiastic support for more use of sensors.

The authors believe that the academic community can contribute more to New Zealand conservation values and renewed biodiversity, particularly through Predator Free 2050, by teaming with industry and non-commercial participants in this field. More activity

mapped on to a standard research method, and published in open-access sources, will result in improved outcomes across for this national campaign.

6.2 Conclusion

The authors have outlined one part of the broad range of work we have undertaken in support of the Predator Free campaign. We hope that the work will be useful to others working in this field and that making our work accessible in this way will encourage those in the field to follow suit and also encourage younger members of our communities to consider taking up science and engineering as an interesting and worthwhile career.

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Forming Team for Cybersecurity and Cyber-Forensics operations using individual profiling

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Abstract

Responses to cyberattacks are often managed by teams consisting of normal workers and several "domain experts" who excel in their specific field. These domain experts have specific personal traits and working habits. A critical question that organisations responding to cybersecurity incidents need to ponder upon is – "*What should the composition of cyberteams look like?*" Peer reviewed research is surprisingly silent on the aspect of team formation for cyber operations. This experiment is an initial step in creating scalable frameworks to form cohesive, effective and balanced teams to conduct successful cyber operations. The research/ experiment has been set in an academic backdrop yet offers its participants a near real life experience that mimics the industry. The research has run for two semesters of 6 months each at Wintec for students of undergraduate and postgraduate IT programs. A special profiling software called PeopleMaps was used for personality profiling. The quality and timeliness of results post a cyber operation, team-dynamics within a team, and completion rates on the given cybersecurity and cyber forensics tasks were taken as metrics of performance. 30 teams of students participated in the experiment. The results obtained from the experiment, thus far, create a sound base for the researchers to hypothesize that individual profile inspired team creation leads to a better balance in a team and thus higher performance in cyber related tasks vis-à-vis teams created only based on kinship or personal affiliation. This experiment is now being extended to other academic modules to validate the results obtained for a cybersecurity experiment.

Keywords

Cybersecurity, Cyber Team Dynamics, Team Formation, Cyber Forensics, Cyber Operations

1. Introduction

We live in an increasingly complex, socially interconnected, and ever-changing cyber space today, where algorithms are governing access and exposure to our online reputation and personal information. The level of cyber risk for all organisations, including those that may not expect to be targeted in yesteryears, has increased

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manifolds. An accelerated unauthorized exposure to sensitive personal information, access to critical systems and critical information has been witnessed since the onset of the COVID pandemic. There is an urgent need for effective, economical, and cohesive plans to deal with cyber accidents/incidents arising all over the business, academic and governmental landscapes. This research is an attempt to address the emerging cyber landscape's severe skills shortage, provision of reliable and ready resources by using an "optimization of team dynamics" approach.

Cybersecurity is, by nature, an interdisciplinary topic at an individual level and multidisciplinary one at a team level. Conducting cyber tasks, under severe time constraints are complicated operations. Responses to cyberattacks are often managed by a team of people from the same or from different organisations, companies, government agencies as well as private institutions having the requisite expertise to handle the situation. These teams normally consist of several "domain experts" each excelling in their specific field of knowledge. Each domain expert has his/her own unique personality that impacts on how they contribute their skills and knowledge to the team effort. While the role of individual domain experts is undoubtedly significant, the shortage of such resources is the single biggest problem facing the cybersecurity industry today.

This research builds upon a previous study where Ako based techniques were employed to create scenario-based approaches to teaching and learning in tertiary education, adopted at the Waikato Institute of Technology (Wintec, 2017; Valle, Khanna, & Prabhu, 2018). This study takes a step further and bases its research on the analysis of student performance in simulated, scenario based cyber security exercises at Wintec.

The premise of this study is based on our belief that cyber resilient work force development hinges primarily on understanding how to challenge, assess, and rapidly develop human cyber skills in a realistic cyber operational environment. This research proposes a working framework, called Cyber Profiler (CYProfiler), for creating cyber-incident response teams.

This is done by identifying the tenets of a good cyber team, grouping the members together and viewing their performance in resolving simulated cyber incidents in an academic setting. The remaining part of the article proceeds as follows: Section 2 presents a brief literature review of the current developments in the field of creating effective teams for cyber security. Section 3 presents the design considerations of the CYProfiler framework. Section 4 discusses the results obtained from the two semesters of observations. Section 5 concludes the article and recommends improvements to our work and plans for developing the concept further.

2. Literature Review

The digital and virtual nature of the cyber domain notwithstanding, the dynamics of cyberspace hinges upon the fact that they are fundamentally human, and adversarial. Buchler define this relationship beautifully as "the human dimension of cybersecurity involves the dynamic interaction of attackers, defenders, and users. Users pursue their

defined goals (work and personal) that often require interacting with others and online systems using networked technology. Attackers seek to exploit both networked system vulnerabilities and increasingly the user community with social engineering attacks, whereas defenders monitor systems and attempt to thwart and mitigate any actions taken to compromise them." (Buchler, et al., 2018). While there are several studies in reviewed literature that discuss the aspects of the "user" in the cyber matrix, specific studies pertaining to how the "defenders" team should be formed are very few. Bishop et. all discuss the aspect of internal threats and how good team building can negate insider threats by creating a culture of competition and increased collaboration (Bishop, et al., 2014). The study however stops short of recommending an approach to forming teams. Reason, in his book The Human Contributions highlights the human contribution and issues to cyber safety (Reason, 2017) and focuses on the aspect of creating relevant virtual as well as face to face relationships that are needed in times of a cyber crisis. In his book, he also documents, very lucidly, the cases of human contribution to reliability and resilience of complex and safety-critical systems (pp. 78). He goes on to reflect upon the impact of human behavior on a team's continued optimal functioning in a cyber crisis.

While a significant portion of peer reviewed academic literature discusses the individual "expertise" desired or required of a team handling a cyber crisis, this research's proposition is that human analysts are crucial in developing proper situational awareness and executing effective strategy, when working together and as a team. Cyber defenders do not work in isolation but as part of a cybersecurity team, and mastering cyber operations requires understanding what constitutes effective cybersecurity teaming, learning, competition, and reasoned profiling of members (Brase , Vasserman, & Hsu , 2017). Examining effective teaming among cyber defenders involves the understanding of specific compositions of skills and expectations from roles required as team-members. It also means appreciating team-processes such as collaborative interactions and presence of effective leadership within a team that may lead to successful conduct of cyber operations. Some research is available on the specific conduct of simulation exercises in cyber-military settings where the role of leaders, defenders and even the attackers has been illustrated. In specific, Malviya et al and Granasen and Andersson mention that the role of effective team bonding is critical for successful conduct of a cyber operations team (Malviya, Fink, Sego, & Endicott-Popovsky, 2011), (Granasen & Andersson, 2016). Cyber exercises in academic settings make use of simulation environments which provides some degree of experimental control, offers critical oversight, hinged on the experience of members and moderators. The outcome in such an exercise is measured on the performance score doing specific tasks. A cumulative analysis constitutes the overall team effectiveness.

Often, authors have based their research on team competitions that are driven by a scenario that combines legal, ethical, forensic, and technical components in teaching the essential tenets of safeguarding the operation of critical information and its supporting infrastructure against envisaged opponents. This research also added the element of time constraints as a metric to the equation. Seamless communication and collaboration of members of the team, supported by the tenets of leadership are necessary to handle the demands of applying practical information and security skills in such scenarios with

intense time pressure to perform against the clock. Teams that work together succeed and those that don't, falter, often tending to fail at critical moments. Effectiveness of these scenario based approaches has been discussed at length by several authors in peer reviewed literature (Hockings, 2010), (Knowles, 1978) and (Smith, et al., 2008). Our previous article on this subject also mentioned this at length (Valle, Khanna, & Prabhu, 2018) and (Khanna, 2019).

Despite existing industry research on the topic of cyber operations and cyber team expectations, there is a conspicuous void in terms of peer reviewed academic literature on quantitative assessment of the cognitive aptitude, work roles, or team organization required by cybersecurity professionals to be successful. Dawson and Thompson in their article describe the apparent lack of analysis devoted to specifying what attributes the individuals in the cyber domain need (Dawson & Thomson , 2018). They cite that research which exists tends to place an emphasis on technical and engineering skills while discounting the important social and organizational influences that dictate success or failure in everyday settings. Their research then goes on to argue that team dynamics and social fitting within a team environment engaged in cyber operation is equally important. In another interesting article, Brase et al contest the description of people engaged in cyber operations as being limited to metaphorical mental models like disease risk, physical security risk, or criminal behavior risk. They conduct a statistical experiment to identify some effects on patterns of responses, including the behavioral likelihood ratings (Brase , Vasserman, & Hsu , 2017).

The next section describes the design elements for the proposed framework for creating better cyber security teams.

3. Design Considerations for the CYProfiler Framework

3.1 Research Objectives.

Creating teams proficient in providing timely, relevant and scalable cyber security operations is a non-trivial task. Team dynamics, and in particular, team composition is a critical factor that largely determines whether a team will be able to:

- perform under pressure
- collaborate within and out of the team boundaries
- communicate effectively
- eventually deliver the correct actions during a cyber crisis

The overarching vision of this research is to achieve a repeatable process, which can be extended to every aspect of team building for cyber security operations.

The specific objective of this research is the provision of a scalable and effective framework which could be used by organisations to create effective, balanced and skilled cyber operations teams. The framework should also be general enough to pivot a team's composition once the nature of the cyber operation undergoes changes.

This paper however focuses on two specific cyber operations for which the process was tested, operationalized and then executed over a year, both in face-to-face simulations and then in a virtual academic environment.

Teams consist of resources (people) with varying degrees of domain specific or generalist skills, who come together to achieve a common objective. To achieve this in other domains outside of cybersecurity, organisations tend to use the overly simple, yet often utilized Pareto Principle to select a domain expert and then club him or her with others in supporting roles (Juran, 2016). Creating teams using this approach in any situation, particularly in cybersecurity operations, can be high-risk. The varied nature of technical as well as cognitive skills or human attributes that are needed to address cyber crises complicate the process of team formation. The nature of cyber operations is such that each phase or stage of a crisis needs a different skillset and different personalities to be present in a team. No organisation will always have the requisite skill sets or personalities to a handle every type of security issue. Thus, organisations need to identify which skillsets and personalities it can source internally, and those which should be outsourced to create well rounded teams. For this research the desirable result to be achieved by a team was to secure itself and the organisation from cybersecurity threats, and effectively handle the restoration of services to a normal level, if a threat has been enacted as a hack.

3.2 Research Methodology and Profiling Tool

A scalable team composition framework is feasible only if it enables the team to complement the strengths of its members, cover the weaknesses of some by providing an alternate skillset. A good team should be able to achieve synergy through cooperation and communication. Creating such teams needed interaction with students who would participate in the research and get inputs from the industry and other academic professionals engaged in related fields of work and finally detailed profiling of members.

The use of a personal profiler or a psychometric tool, specifically, PeopleMaps was chosen to conduct the profiling report for each team member. The tool was selected because the reports generated by the system were to be shared with a technical audience and was therefore needed to be psychological jargon-free and in a simple language. It did need some training for the tutor/moderator to create the teams using the system's backend, as it existed in April 2020. The system has matured now and has a very simple interface to create a survey and share with the participants. An excerpt of the survey form is depicted in figure 1 below. The system's internal working and the psychometric evaluation logic will be discussed in another paper which is being concurrently worked upon by the research group.

The process for the framework was initiated after conversations with cyber leaders in the industry and students who were willing to participate. The members from the industry, and the students, involved in the research were briefed in advance on the processes and timelines of the research.

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There was no video or audio data collected during the verbal feedback with stakeholders prior to the start of the research. No personally identifying information (PII) was used in any of the evaluations or feedback collation. There were 85 participants, all students, in the experiment that was conducted between April 2020 and May 2021. The participants were briefed individually about the research project at the beginning of the semesters and teams were formed. The teams were again briefed on the specific reasons as to why the team composition was special. Explicit verbal consent was taken prior to this research. Participant teams were not paid for their participation. They were all provided a copy of their personal profile report and finally thanked for their participation in the research. Some students wanted to participate in the research, but wanted to form their own teams. Such members were allowed to do so and became part of the "independent teams". Details of such teams are mentioned in the next section.

Figure 1. Survey using a PeopleMaps interface for participants.

3.3 Desirable Attributes for Selection of a Team.

The attributes which define a successful cyber team find some mention in literature (Granasen & Andersson, 2016), (Brase , Vasserman, & Hsu , 2017), (Bishop, et al., 2014), (Malviya, Fink, Sego, & Endicott-Popovsky, 2011). The members of this research also conducted a survey and held a series of interactions with relevant stakeholders in the industry. Surveys and interviews were the tool used for obtaining inputs on the salient attributes of members in a team. These interactions were conducted between January 2020 and March 2020, and then again in Feb 2021.

Major inputs were also derived from US Department of Homeland Security's Cybersecurity Workforce Framework (Newhouse, Stephanie, Benjamin, & Greg, 2017). The set of attributes desirable in members conducting cyber operations were analyzed from a team's cohesion, team dynamics and team performance perspectives. This research team decided, after detailed interactions and consultative research that specific

technical skillsets to handle a cyber forensics exercise, and a blue team cyber operation exercise were sufficiently general cyber operations to cover a wide range of skill needed for a composite cyber team. The scenarios made for the research exercises were then created to measure relevant skills needed in a team tasked to conduct such an exercise.

Based on the research and interaction, following key attributes emerged as essential within a team to conduct a successful cyber operation:

- **Leadership** – A person should possess skills to lead a team of domain experts, have sufficient technical skills to manage and understand the intricacies of the business impact of the incident, while being mature enough to take key decisions in the event of a crisis.
- **Attention to Detail** – The team should have natural attention to detail as forensics is a detailed art needing patience and the capability to register minute details.
- **Adherence to Deadlines** – Perfection is a desirable attribute, but in the case of an actual cyber incident, deadlines are often more critical than achieving a perfect solution. Members who can work to a tight deadline are invaluable in such situations.
- **Action over Reflection** – The attribute of responding to a situation and taking a decisive course of action is often more effective than only reflecting and procrastinating.
- **Big Picture over Details** – A team member who has the ability to understand and appreciate the bigger picture and one who possesses lateral thinking is invaluable in a cyber team.

There were other attributes which were recorded during the interaction with industry partners and obtained from the NIST framework (Newhouse, Stephanie, Benjamin, & Greg, 2017), but for this research we decided to limit our focus to specific skills and personality topics which were required only for the chosen cyber exercises.

3.4 CYProfiler Framework Steps

The generic steps to implement the framework for any organization are as under:

- **Attribute Gauge Selection** - The team attributes needed for a cyber exercise are selected a priori.
- **Question Selection for Participant Survey** – A series of relevant questions are selected from the personal profiler survey bank. This step creates a base for the psychometric profile composition of the team.
- **Creation of the Survey and its Distribution** – The survey is then created distributed to the members of the team(s). There is a deadline to answer the survey.

- **Review of Individual Survey Results** - Survey results are computed by the profiler and the results are shared with the participants so they become aware of their personality attributes.
- **Consolidation Workshop and Team Creation** - The survey results, also available to the moderator, are discussed by management and teams created based on a balanced mix of skillset derived from the profiler. The objective is to cover all skills needed for a team's role or a situation, compatibility of skills and other cognitive attributes. The team members are made aware of each other's attributes and skillsets and can work to enhance each other's strengths and mitigate for weaknesses pertaining to the specific task at hand.

The framework map and its steps for implementation are depicted in the image in figure 2.

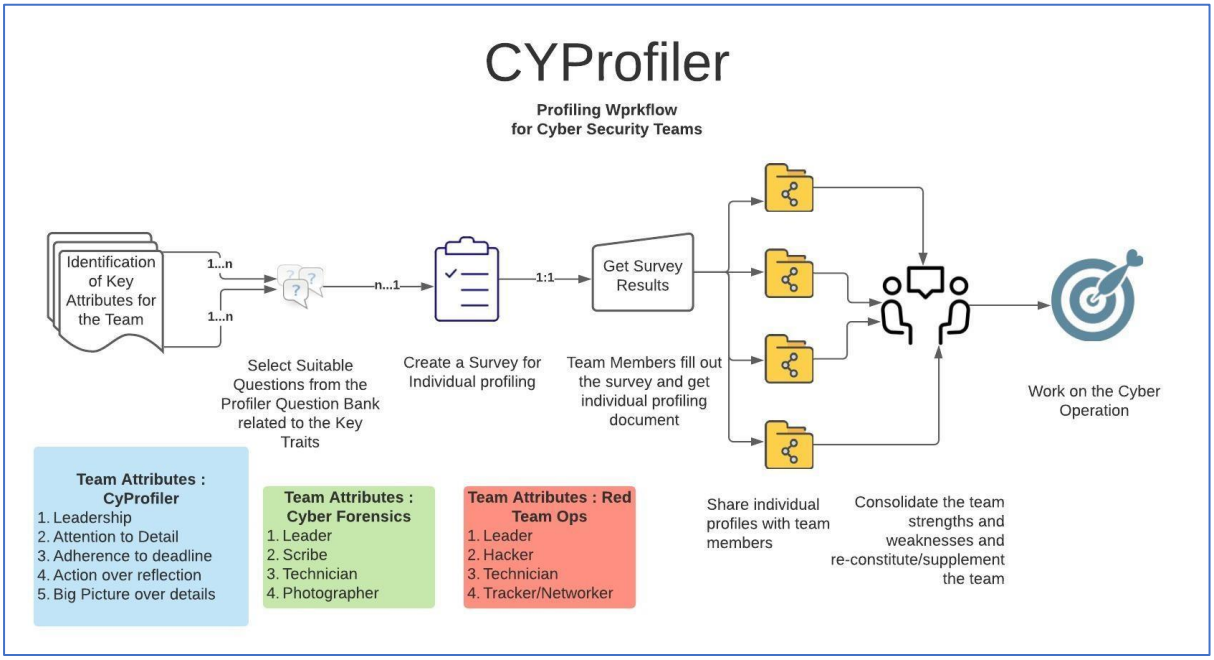

Figure 2. CYProfiler : A framework for creating cyber teams

The steps in the CYProfiler framework are generic enough to be moderated for composing teams required for any cyber task. The framework has intentionally been made generic to allow relevant stakeholders to pivot a team's composition based on strengths of a team. Managers/tutors can also address specific voids based on the specific cyber situation.

3.5 Experimental Model for CYProfiler

The experimental model for team creation and the experimental setting was created using 2 different scenarios for the Postgraduate teams and 20 scenarios for undergraduate teams. The experimental structure and the scenarios used for the CYProfiler experiment are depicted in figure 3 below.

In general, the participants were distributed into two classifications of teams, the independent team and the controlled team. As the student groups were distributed between postgraduate and undergraduate students, scenarios for the experiments were also created at different levels of complexity. For the post graduate teams, two separate scenarios were created that addressed specific gauge skills mentioned in section 3.3 above. 48 participants in the postgraduate segment were further sub divided into 12 teams consisting of four members each. 6 teams in the controlled groups worked with “Scenario 1” and three teams were tested on “Scenarios 2.”

To compare the performance of the control groups, three independent teams were created. Two independent teams were tested on “Scenario 1” and one team on “Scenario 2”. The independent teams consisted of students who wanted to form groups with their friends and known colleagues. The independent teams were treated as comparison groups as their metrics of constitution was different. Although their composition was based on their kinship with the other members, the independent teams sat the survey and were provided their profile info. Internal discussions were held amongst them to deal with skill coverage. They underwent the same profiling process as the controlled teams, however, intra-team dynamics were treated as an ignored variable in their case.

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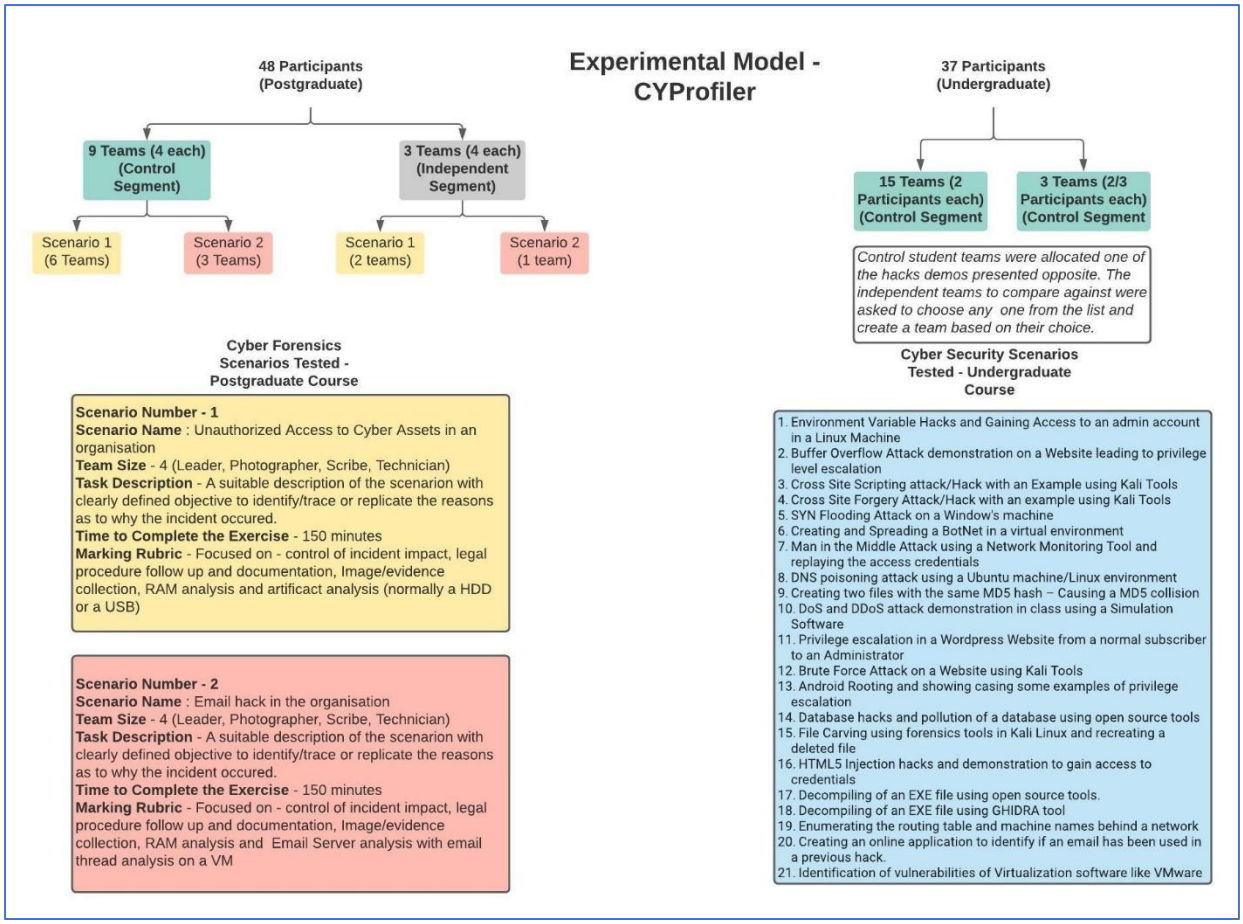

Figure 3. Experimental Design for CYProfiler with scenarios and team distribution for the control teams and independent teams.

Similarly, in the case of undergraduate teams, 37 students were distributed amongst 18 teams comprising 2 members each. The controlled group consisted of 15 teams. There were 3 independent teams comprising 2 or 3 students each. The reason for the creation of the independent teams was similar to the postgraduate one. In the case of the undergraduate teams, the scenario was to demonstrate/exploit a cyber hack under time constraints and work as a team to resolve or enact the same. A total of 21 scenarios were offered and teams asked to select one from the list. The independent teams were asked to choose any one from the already selected list to ensure fairness of comparison.

The experiment was observed by 3 independent moderators. The cyber exercise lasted 150 minutes each. The average of the marks provided by the moderator were assigned to teams as final grades. The moderators were not made aware of who the independent teams in the experiment were. This was done to ensure removal of any silent or overt bias. A detailed feedback from the students was taken post the experiment on the team dynamics, in addition to the presentation on the hack solution.

The next section describes the results of the experiment since April 2020, till May 2021.

4. Results and Analysis - CYProfiler Framework

The metrics or gauges for skillsets selected in the previous section were adopted after prolonged and detailed analysis of the key traits needed by a team to conduct cyber operations. The scenario-based approach to learning, adopted for the experiment tested each team on a uniform basis. The attributes/skills gauge matrix created for the profiler software is depicted in figure 4 below. Cyber scenarios created for the teams addressed the validation of the skill gauges in figure 4 at a cognitive as well as a technical level. The impact of a time constraint added the layer of urgency to the experiment. The specific attributes desired from the members to handle a cyber incident identified during the metric analysis were mapped to key profiling queries. A score of 70+ signified possession of those qualities by the members.

	Meeting Deadlines	Scribe	Big Picture	Lateral Thinking	Team Spirit
Map Location	**NE, N, NW, W**	**SW, S, W, NW**	**NW**	**NW, W, N**	**E, SE, S**
Gauges					
4136 Prioritises deadlines over perfectionism	70+				
4137 Prioritises big picture over details			70+		
3872 Natural Attention to Detail		70+			
4144 Prioritises Action over reflection	70+				
3908 Collects and analyses data		70+			

Figure 4. Skill gauge matrix for the experiments with the gauges mentioned and the likely placement from a cognitive view-point and keeping in mind the team dynamics.

4.1 Postgraduate Results and Analysis – Cyber-forensics tasks

It was observed during the team creation stage that a majority of students possessed an abundance of a specific skill, while some skills needed for an experiment were absent. This use case is often seen in the industry as well, where teams often tend to have abundance of a specific skillset, while lacking in another needed to conduct the operation successfully. In such situations a compromise is needed. An even spread of adequate skillset possessing students, akin to “domain experts” are grouped within teams which lacked critical skills. The comparison of results between the controlled teams and independent teams validated this to be a correct assumption and a fair distribution.

The following 4 metrics were evaluated as measures of performance of the team:

- Quality of results,
- Timeliness of results,
- Working efficiency within a team,
- Completion rates on given security and forensics tasks.

The comparison was made amongst the controlled teams and then again between controlled and independent teams. Figure 5 indicates the metrics score of all teams at the postgraduate level and highlights the abundance of a specific score over 70 as part of a team.

Team	Flag	Other to Speak	Speaks Up	Ensures adherence to procedures.	Unlikely to be over cautious or hesitant.	Prefers to work on detailed and precisework	Prioritises deadlines over perfectionism	Prioritises big picture over details	Natural Attention to detail	Naturally deliberate and methodical.	Prioritises action over reflection	Results focused.	Puts their team's needs first	Prefers to work alone	Prefers when everything is a team effort	Collects and analyses data	Quick thinking, decisions and reflexes	Cooperates well with colleagues	Naturally good at prioritising tasks
Team 1	NE	54	80	50	97	18	88	89	32	31	93	94	55	82	55	61	92	59	82
Team 2	S, SW	96	44	82	30	72	31	48	89	88	50	48	92	25	98	68	42	84	59
Team 3	SE	71	56	70	47	48	90	95	54	65	75	55	79	40	73	58	64	85	54
Team 4	NW	61	40	88	27	96	16	31	95	93	33	70	48	80	35	98	54	52	88
Team 5	N	58	75	75	50	40	70	65	84	48	74	87	48	97	12	91	70	45	85
Team 6	E	59	90	54	94	9	90	92	28	40	90	84	57	70	41	55	90	74	70
Team 7	C, NW	44	72	70	40	71	56	60	89	56	70	82	52	80	30	96	75	50	80
Team 8	S, C	96	44	82	30	72	31	48	89	88	50	48	92	25	98	68	42	84	59

Figure 5. Teamwise scores on key skills across the teams. The items in red highlight the scores which are predominant in the team support the teams during the operations.

Figure 6 highlights the average skill score of the teams based on the skill distribution of members. The composition of teams was done to ensure that all controlled teams are equally skilled in applying the cognitive as well as technical skills during the experimental scenarios. The normalization of the skills helped the teams to achieve higher scores on cyber tasks than previous semesters, and even score higher when compared to independent teams doing the same task. The min average skills score on the team was 61.39 and the max skills score of a team was 67.33 indicating that the peak skill differential was only 5.94, without a technical bias.

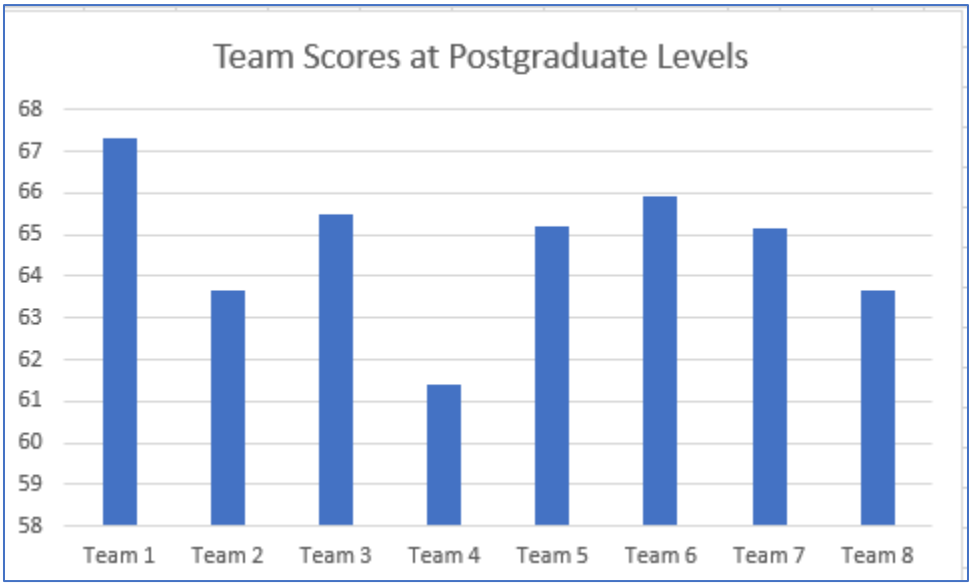

Figure 6. Team scores at postgraduate levels for the average overall skills within a team highlighting that the distribution of skills across teams is optimal.

The skills to performance comparison, in figure 7, shows a positive correlation and supports the hypothesis that a balanced and skilled team out-performs an unbalanced team, with equal or different technical skills while handling cyber tasks. The high coefficient of correlation between skills scores and performance also enhances the validity of the research assumption that diverse, yet balanced teams tend to perform better in cyber tasks. The low p-value indicates that the Null Hypothesis assumed is also valid.

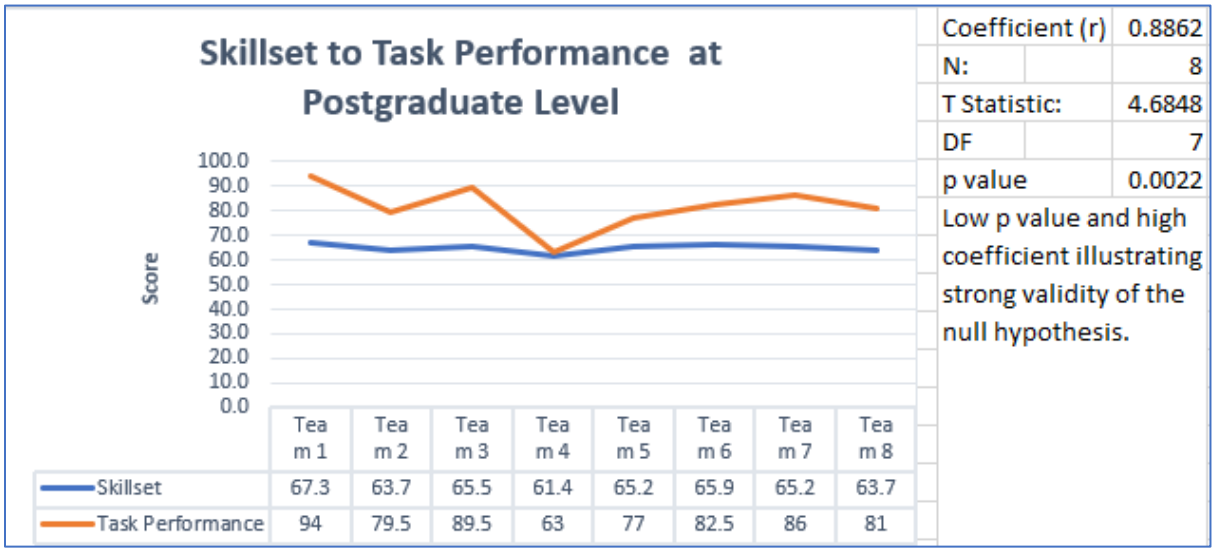

Figure 7. Skills to task performance of postgraduate teams illustrating the positive correlation between the two metrics. The low p value indicates the validity of the null hypothesis.

4.2 Undergraduate Results and Analysis – Cybersecurity tasks

While comparing the results of the teams at the undergraduate level, it emerges that having equitable skill distribution amongst teams consisting of only 2 members is a challenge. The way to overcome this issue was to allow the teams to choose one task from over 20 available and mentioned in Figure 3, thus allowing a partial technical bias in the experimental, but retaining cognitive independence. The skill distributions and scores of 12 teams at the undergraduate level are illustrated in figure 8. Figure 9 highlights the average skills scores of the undergraduate teams. The distribution of skills within teams was not evenly distributed, the average difference across skills is in the case of undergraduate is 9.5 which is significant. The need to introduce a technical skills bias was thus necessary here.

Team	Flag	Other to Speak	Speaks Up	Ensures adherence to procedures.	Unlikely to be over cautious or hesitant.	Prefers to work on detailed and precisework	Prioritises deadlines over perfectionism	Prioritises big picture over details	Natural Attention to detail	Naturally deliberate and methodical.	Prioritises action over reflection	Results focused.	Puts their team's needs first	Prefers to work alone	Prefers when everything is a team effort	Collects and analyses data	Quick thinking, decisions and reflexes	Cooperates well with colleagues	Naturally good at prioritising tasks
Team 1	S, C	45	96	52	93	40	90	95	30	38	98	59	61	63	72	45	73	80	59
Team 2	E, S	71	56	70	47	48	67	70	54	65	75	55	79	40	73	58	64	85	54
Team 3	W, S	73	39	86	19	70	11	30	90	97	40	62	70	14	77	90	41	60	74
Team 4	C, S	70	40	85	15	78	19	33	85	92	46	46	80	32	76	80	32	57	70
Team 5	S	70	55	75	52	52	65	66	70	70	69	53	80	10	90	60	50	86	58
Team 6	E	59	90	54	94	25	90	92	28	40	90	88	57	70	41	55	90	74	70
Team 7	S	96	44	82	30	58	31	48	89	88	50	48	92	30	93	68	42	84	59
Team 8	W, S	73	39	86	19	84	11	30	90	97	40	62	70	40	72	90	41	60	74
Team 9	S, C	94	46	80	35	70	49	52	78	79	55	46	96	14	96	64	36	89	49
Team 10	E	36	92	56	96	17	99	98	25	35	96	62	59	72	63	51	89	78	60
Team 11	N	58	75	75	50	40	70	65	84	48	74	87	48	97	12	91	70	45	85
Team 12	S, W	96	44	82	30	70	31	48	89	88	50	48	92	16	81	68	42	84	59

Figure 8. Skill distribution for teams at undergraduate level. The red elements signify a higher distribution of specific skillsets.

The team skill scores at the undergraduate level had more variance and illustrate the common problems observed in the industry having smaller teams handling cyber tasks. Optimal matching of skills is critical in such situations and while handling critical cyber tasks.

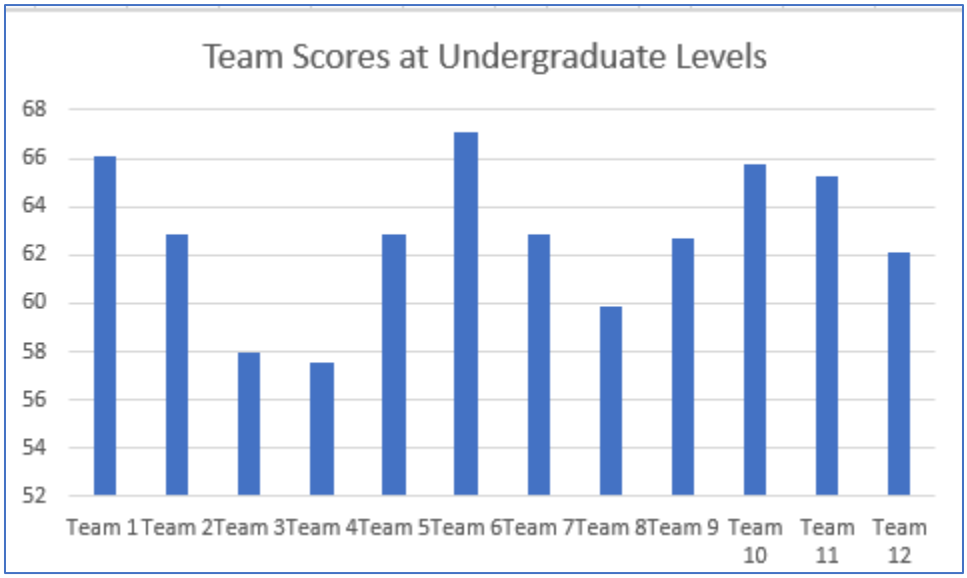

Figure 9. Team Skill scores avarages at undergraduate level.

The skills to performance comparison in figure 10 highlights that the correlation is positive and the low p-value once again signifies the validity of our null hypothesis that well balanced teams lead to better performance on tasks related to cyber security.

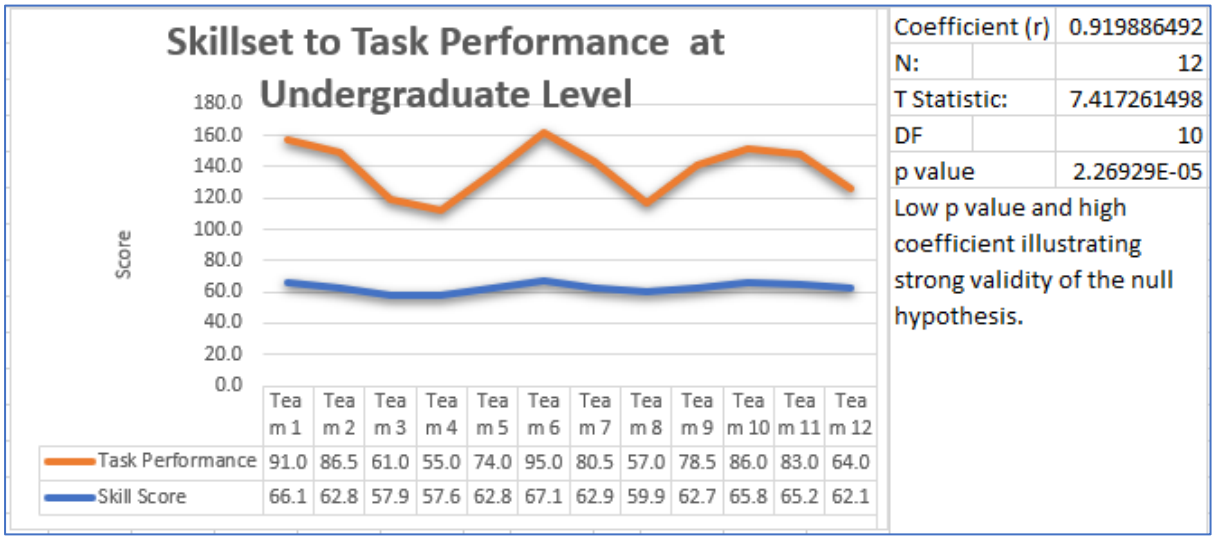

Figure 10. Skillset to task performance of undergraduate teams highlighting a high correlation of .91 and a very low p value of .000269 signifying the trueness of the hypothesis for the research.

The postgraduate and undergraduate results obtained above illustrate a strong positive correlation between the team skill scores and their performance on the tasks related to cyber security. The results also have a low p value which suggests that the null hypothesis we adopted is also valid. The undergraduate results showed highly varied skill scores, and the performance scores also reflected similar distribution.

5. Conclusion and Future Work - CYProfiler Framework

The research has provided a clear pathway for progressing with the development of the framework to address other types of cyber operations and mapping key skill attributes to measurable cyber performance. It also brings to fore the fact that domain experts, though very valuable in a cyber crisis, are not as effective alone, as they would be in well-balanced teams. Though this is an intuitive deduction, it follows closely from the trends visible in the research.

This research was conducted with 85 participants divided into 30 teams across postgraduate as well as undergraduate levels pursuing an IT program at Wintec. The skills to performance metrics observed during the experiment shows a positive correlation between the two metrics. The p value is also low suggesting that the null hypothesis that balanced teams perform better is true.

The experiment was conducted only for two types of cyber operations and in future, there is scope to enhance this framework to further testing using different types of cyber operations. It is also envisaged that the framework can be used by management in general by using a personal profiler to map teams pursuing an IT operation and achieve better results.

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A Comparative Study of Cross-platform Mobile Application Development

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Abstract

Mobile applications development has increasingly become crucial as the number of mobile phone users has grown exponentially. However, it is even more difficult for developers to build applications that are efficient and effective than ever before, because of multitude of functions that are needed to be implemented in both Android and iOS at the same time. This study explored and discussed the approaches and applications in cross-platform application development through an experimental methodology. Therefore, a sample project was implemented with the native framework and then with three cross-platform frameworks, such as React Native, Flutter, and Xamarin. The data from each project was collected and analysed in terms of functionality, workload, development procedure, and performance in order to find their advantages and disadvantages. Finally, the study compared these three cross-platforms and also compared them to the native framework, and then draw a conclusion of which cross-platform framework is the best for mobile application development.

Keywords

cross-platform mobile development, android native, react native, flutter, xamarin

1. Introduction

Mobile applications development has increasingly become crucial as the number of mobile phone users has grown exponentially. However, it is even more difficult for developers to build applications that are efficient and effective than ever before, because of multitude of functions that are needed to be implemented in both Android and iOS at the same time. Therefore, cross-platform development using a native developing approach was proposed in order to be more efficient and productive for developers (Xanthopoulos & Xinogalos, 2013).

A recent study showed that although there were many existing cross-platform frameworks or libraries in mobile development, few of them were accepted widely by developers, such as React Native, Ionic, and PhoneGap (Biørn-Hansen et al., 2019). In 2020, Flutter and Xamarin became very popular frameworks.

The goal of the research is to answer the following three research questions: 1) how do these frameworks improve development efficiency compared with native development; 2) what are their limitations; and 3) which cross-platform framework is the best.

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2. Literature Review

Nowadays, smartphones have become increasingly important since the first release of the iPhone. There are two mobile systems that dominate the market, namely iOS and Android. They are built with different architectures, programming languages, and frameworks. Consequently, programmers must implement twice by using a platform-dependent programming approach, which revealed that cross-platform technologies are more efficient and productive for application programmers (Xanthopoulos & Xinogalos, 2013).

According to Biørn-Hansen et al. (2019), although many cross-platform technologies were emerging before 2015, such as Ionic, PhoneGap, and Titanium, none of them was used widely because of poor performance and inferior stability. The research also suggested that React Native, Flutter and Xamarin were becoming increasingly popular due to better performance and robustness.

2.1 React Native

React Native is a cross-platform framework developed by Facebook (Danielsson, 2016). The goal is to use only one programming language and framework to build mobile applications. It is a derivative of React, which is an open-source JavaScript (JS) framework from Facebook in the native mobile platform and supports iOS and Android platforms currently (Gill, 2018). Although it may need little effort of learning for those who are familiar with Web front-end development, React Native enables developers to write native mobile applications only using JavaScript programming language. It is consistent with React in terms of design principles and declarative component mechanism in building a rich User Interface (UI).

The advantages include: 1) it uses JavaScript to composite various components; 2) it transforms mark-up elements into native UI elements; 3) it separates the working thread from the main UI thread, which results in a better application performance with full functionality; and 4) it significantly saves time in terms of development and maintenance (Kravtsov, 2018). Conversely, the disadvantages include: 1)it does not support What You See Is What You Get (WYSIWYG) in UI Design (Gu et al., 2017); and 2). it requires platform-specific code to implement some functions (Cantù et al., 2018).

2.2. Flutter

Flutter is a free mobile application Software Development Kit (SDK) released by Google. The goal of Flutter is to deliver high-performance applications on Android and iOS platforms rapidly and smoothly. In a study by Cheon and Chavez (2020), Flutter, using neither WebView nor JavaScript, implements a UI framework by itself. It transfers UI components and renderers from platform to application, which makes them customizable and extensible. It only requires the system to provide a canvas so that customized UI components can appear on the device's screen, which is the key to be cross-platform and efficient. In addition, Flutter implements a state machine that is used widely in React Native to render the minimum changed area when updating the UI (Fayzullaev, 2018).

The merits include: 1) Dart is the only programming language used in Flutter (Idan Arb & Al-Majdi, 2020). And 2) it can be integrated with Android Studio through plugins, allowing Android developers to transit their work seamlessly (Dagne, 2019). The drawbacks include: 1) the plugins do not support WYSIWYG in UI design. And 2) it highly depends on components that were published in their community (Fentaw, 2020).

2.3. Xamarin

Xamarin is a cross-platform solution that aims to build iOS, Android, Mac, and Windows applications. In a study by Delia et al. (2015), the Xamarin application runs efficiently as a native one because it employs native controls and Application Programming Interfaces (API). Also, Xamarin creates a bridge to allow the platform-specific library can be called directly using C#, which is a mainstream programming language in the Windows platform. Furthermore, Xamarin also supports the .Net Standard library used in its projects, which expands the range of options during the developing period (Radi, 2016).

The advantages include: 1)it uses the C# programming language, which is quite similar to Java, so that the Android Native developers can rapidly study (Al-Bastami & Naser, 2017); 2)it is integrated with Visual Studio (Radi, 2016), which is the most powerful Integrated Development Environment (IDE) on Windows; 3)it can generate high-performance programs in an experience similar to native development (Willocx et al., 2016); and 4) it supports downloading components from the NuGet extension (Martinez, 2018), which accelerates the developing speed significantly. According to Avdic (2019), the disadvantages include: 1) it cannot support the latest native framework in time; and 2) it is not stable.

Although Flutter was considered better than React Native in UI performance (Jagiełło, 2019) and Xamarin was reflected as efficient as Android Native in terms of encryption processing speed (Dobrzański & Zabierowski, 2017), there is lack of study comparing these three cross-platform frameworks directly based on building a practical project. Furthermore, there is also lack of research comparing their characteristics beyond their performance, such as functionality, workload, and applicability, which is the knowledge gap that this paper is endeavouring to fill.

3. Research Methodology

3.1 Data Collection

The experimental methodology was applied in this study. The research developed a sample practical project, a coin wallet application based on block-chain, in order to answer the research question. The sample application was implemented in Android native and three different cross-platform frameworks respectively. Table 1 shows the data to be collected from each application. Most of the data, such as UI Design, functionality, and workload were collected through the process of the development, while the performance data was collected using the “mobileperf”, which is an open-source tool for monitoring performance, such as CPU and memory usage.

Table 1. Plan of data collection

Type	Description
UI Design	How efficient and friendly are the UI design tools?
Functionality	Whether the framework can meet the functions required in the project, such as cryptographic algorithms, UI elements, and communication with the server.
Performance	The performance of the application, including CPU usage, memory usage, and the size of the release package.
Workload	How much code was written in the project?

3.2 Project Design

The Coin wallet is a financial application running on the phone that allows users to transfer their money to others. The features, such as UI, network communication, and various algorithms, were developed in the sample project. The project contains a server-side and four client-sides (see Figure 1). The server-side is a daemon service running on a workstation to transmit the blocks data to clients. The client-sides include four applications that were implemented by Android native, React Native, Flutter, and Xamarin respectively. To ensure the project can be tested, both server-side and client-side were deployed under a single subnet.

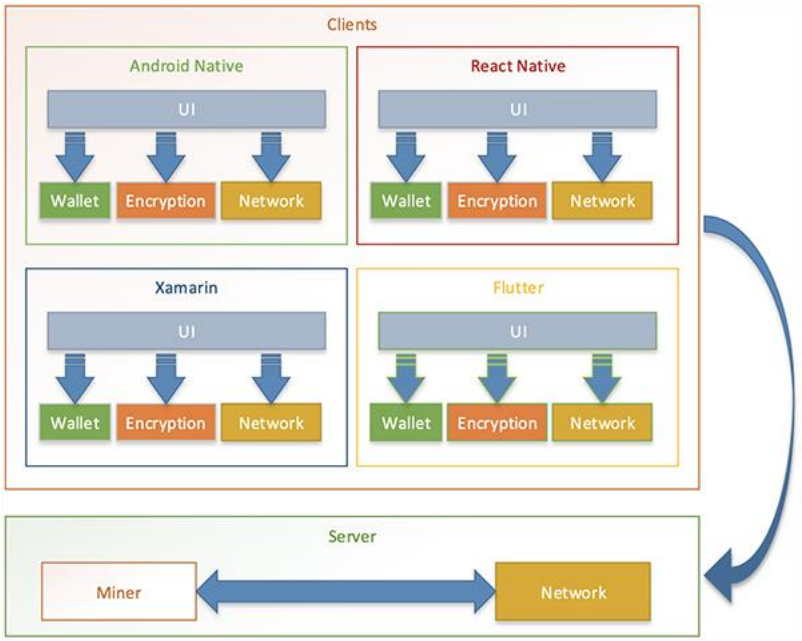

Figure 1. Workflow of Server-Clients architecture

Each client application is composed of the wallet, encryption algorithm, and network implementation. The UI module is in charge of screen rendering related functions by popping up a notification, accepting input text, and presenting rich graphic elements on the phone. The wallet is responsible for transferring or collecting money from others. The encryption module needs to generate, store, and compute the key on the phone. The network module encapsulates RESTful API to make the communication between clients be easy.

An example of workflow for transferring money of $30 from Client2 to Client1 using the sample project is in Figure 2. First of all, both clients need to input the server's IP address in order to ensure all applications communicate through the server properly. Secondly, the receiver (Client1) needs to be ready by clicking the "Collect" button to show its account (QR code). Thirdly, the sender (Client2) is ready of transaction with its initial balance (e.g. $200) by clicking the "Transfer" button; entering the amount (e.g. $30); and scanning the QR code on receiver (Client1) to transfer the money. Fourthly, the receiver (Client1) receives the money and the balance is updated on both clients (e.g. Client1's balance is $30; Client2's balance is $170 = $200 - $30). Finally, both clients click "Transaction" button to check their transaction recorders.

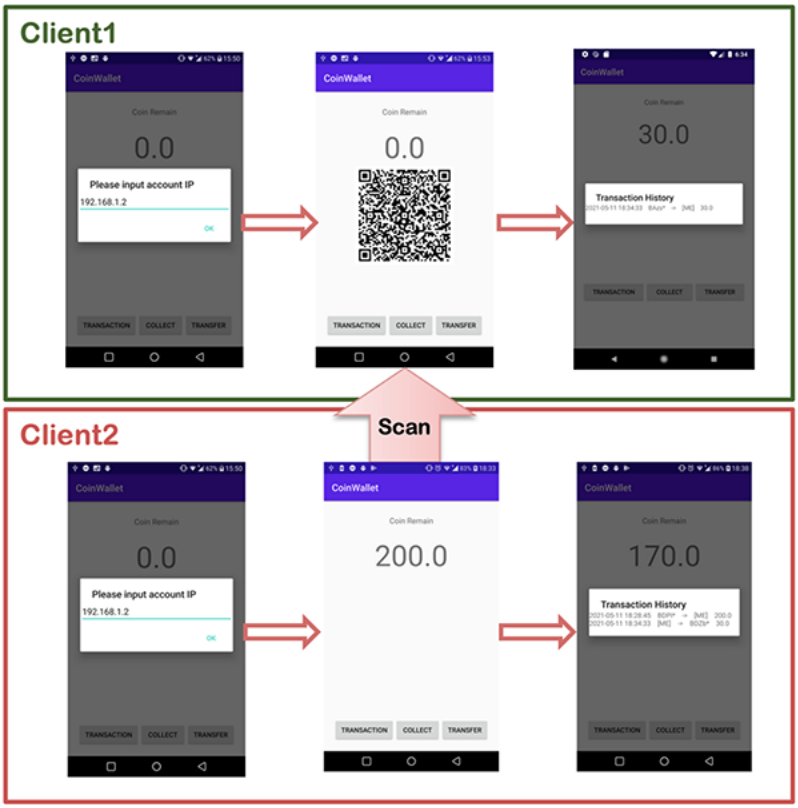

Figure 2. Workflow of applications

4. Research Findings

4.1 Workload

As Table 2 shows, Android Native takes the highest workload in code lines than the other three cross-platform frameworks. Flutter, using Dart in the most concise syntax, requires the lowest workload that is only 47% of the total workload from Android Native. Although React Native costs as much close as that to Flutter on the scale, Xamarin produces a higher workload than both of them.

Table 2. Workload statistics

Workload	Android Native	React Native	Flutter	Xamarin
Java	600	0	0	0
JavaScript	0	445	0	0
C#	0	0	0	524
XML	317	0	0	115
JSON	0	58	0	0
Dart	0	0	432	0
Total	917	503	432	639

4.2 Performance

As to performance shows in Table 3 and Figure 3, the study revealed that the Android Native development takes the lowest CPU usage, the smallest memory usage, and the most compact binary package. Also, the study found that Xamarin runs more efficient not only in CPU usage, but also in memory usage with the smallest binary, while React Native has the lowest performance with the biggest binary package.

Table 3. Memory and APK size comparison

Size	Android Native	React Native	Flutter	Xamarin
Memory Usage	82.67MB	177.92MB	167.45MB	99.78MB
APK Size	3.3MB	30.1MB	21.3MB	12.9MB

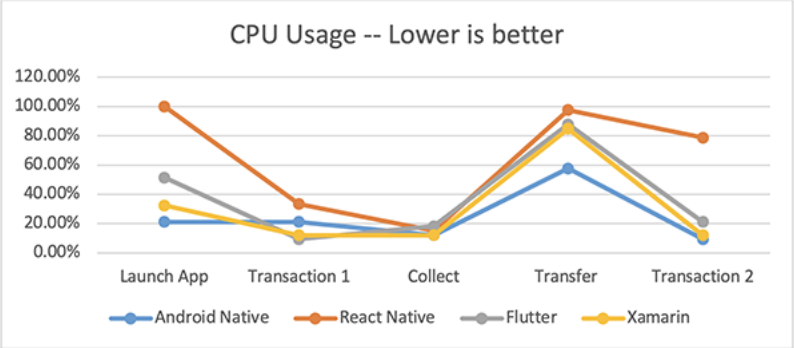

Figure 3. CPU usage chart

Moreover, the study explored that the different development procedure was used among these cross-platforms. Using Android Studio through a plug-in component, React Native divides its development environment into a single tool. However, users must employ a command line to debug and distribute their applications. Using Visual Studio, one of the most powerful IDEs on the Windows platform, Flutter and Xamarin are more user-friendly than React Native.

4.3 UI Development

All the above frameworks can implement the same features of mobile application development. However, users have to face different experience of UI development because each framework has its own characteristics.

Android Studio is an integrated development environment that covers all the life cycle of application development. It provides WYSIWYG experience in code wizards, UI designing, debugging, and deployment. In contrast, React Native divides these processes into several parts that are developed by different single tools. It needs to employ a terminal or command line interface in order to install the environment and also requires to apply different editors in order to edit the code without any auxiliary hint, compose the UI code in the developer's mind instead of WYSIWYG tools. Moreover, both its debugging and publishing application have to go through the command line. In a word, the overall use of React Native is not as user friendly as Android Studio.

Conversely, Flutter is more user-friendly than React Native in the sample project development experience. It utilises Android Studio for code editing and debugging, and for project deployment. It shares the key feature from Android Studio, such as code hint, breakpoint set, variant watch, etc. Although it does not support WYSIWYG, it allows developers to preview the change when debugging.

Xamarin is supported by Visual Studio, which is one of the most powerful IDEs on the Windows platform and provides many features to help developers in their code editing and debugging, and products delivering. It also provides the same WYSIWYG UI design tool as Android Studio. Besides, Visual Studio also has features that allow developers to distribute their applications directly to Google Play and Apple Store. In a word, among the above three cross-platforms, Xamarin offers the best user's experience in UI development for the sample project.

5. Discussion

5.1 Comparison of Cross-platform Frameworks

Since its core is developed by JavaScript, React Native requires an interpreter during execution and rendered UI through native controls. However, Flutter is different because it uses neither WebView nor the native controls of the operating system. Instead, it implements a high-performance rendering engine to draw widgets, which built with C, C++, and Dart programming language. When React Native introduces virtual DOM (Document Object Model) to optimize its renderings, Flutter goes a step further by integrating UI components and renderers into the application, which makes its performance higher than React Native.

Next, it is easy to learn React Native for those who have experiences in web developing or JavaScript coding. On the contrary, Flutter is a new and innovative platform, using Dart language that is not as popular as JavaScript, which means most developers need to learn Dart language when using Flutter.

Nonetheless, Flutter supports Android Studio quite well through plugins, making developers feel like they are using a full-featured IDE, while React Native does not.

Furthermore, Flutter only can be used on the mobile platform, while Xamarin supports Android, iOS, Windows and MacOS platforms, which brings a significant advantage over Flutter. The merit of Xamarin lies in the C# programming language, which is widely used by Windows and .Net developers. Therefore, Developers can use Xamarin directly if they already have C# and .NET programming skills.

Although both Flutter and Xamarin frameworks have powerful IDEs, namely Android Studio and Visual Studio, in order to compile Dart code into machine code, Flutter requires a Dart Virtual Machine (VM) in its running time, which results in decreasing its efficiency. In contrast, Xamarin directly compiles C# code into machine code, which runs much faster than Flutter.

All in all, Xamarin is preferred when the performance is the primary concern or developers are good at .NET technology. React Native is a good choice for those who are proficient in web programming. Flutter is suitable for C++ or Java developers who want to move their current projects to cross-platform projects.

5.2 Limitation

Although all four applications developed by different cross-platform frameworks were run as expected and the data were collected, there were limitations during and beyond the development process, which included:

1. Only limited features were implemented and tested in the sample project, which means it may have exceptions in the performance.

2. During the data collection, all applications were only tested on Android 8.1. The results may vary if using on other versions.

3. During the data collection, all applications were only run on an emulator and a mobile phone, which may lead to inaccurate results.

4. The updates and iterations of all cross-platform frameworks are quite fast. Therefore, the analysis results may vary from version to versions.

6. Conclusion

The study compared three modern cross-platform frameworks through a sample practical project. The results indicate that using an appropriate framework can significantly reduce the workload although all frameworks attempted to achieve the performance in native development. That is to say, different cross-platform technologies are appropriate to different development. Firstly, the Android Native framework is preferred if the project is sensitive to running speed and memory usage. Secondly, React Native is rather suitable for web developers because JavaScript is widely used in web programming. Thirdly, Flutter is recommended for those who are familiar with C++

or Java or who need to port current projects from a native framework to a cross-platform framework because it employs a C-like programming language, Dart. And finally, Xamarin is more suitable for .NET developers or those who are concerned about performance because it is easy to cross-platform development and to implement the most efficient application among cross-platform frameworks using C# in Visual Studio. In one word, considering the limitations above, there is no silver bullet as the best cross-platform framework among them, which is suitable to all the developers in different development background.

For further improvement, the following future works would be considered. Firstly, more features should be involved and tested in various APIs in terms of the performance. Secondly, more devices should be used to reveal whether there are any differences among them, or whether there are any device-independent restrictions. Meanwhile, different devices should run on different OS versions, which can verify whether the data are the same from them. Last but not least, the data should be collected and analysed again after a new update occurs from the frameworks, because each update may include optimizations or degradation.

In summary, all cross-platforms can improve development efficiency greatly, but different frameworks are suitable for different applications and different developers and different scenarios, which means decision-makers need to make choices based on actual projects. The future research would trace the effects of using various cross-platforms for the further improvement.

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Paper Abstracts

(Quality assured)

Virtual and Blended Learning in a Post-COVID World

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Keywords

Blended Learning, COVID-19, Online Learning, Zoom

Abstract

The emergence of Coronavirus and the subsequent national lockdown abruptly forced us out of the classroom and, for many, into the unchartered territory of the virtual classroom. Many students and educators were forced to very rapidly adapt to this strange new digital classroom. An examination of some of the literature regarding online, blended and various forms of virtual learning shows a cleavage beginning to emerge between the pre-COVID orthodoxy and the empirical post-COVID lived experience. For some, the forced pivot to online education offered opportunities to not only re-imagine alternative methods of teaching but to critically examine the traditional physical classroom model. A year into the global pandemic what lessons have been learned?

There have already been several studies published since the global pandemic sent us into lockdowns. Many of these paint a far from rosy picture regarding the transition to online/Zoom style lectures. Langford and Damsa (2020) for example argue that due to time constraints many teaching staff simply tried to mirror in an online environment what they were traditionally doing in the classroom environment. In their study a variety of challenges were raised with only 13% of educators reporting no issues. A recent Korean study (Islam et al., 2020) found that only 7% of students preferred Zoom lectures over alternative methods, such as live face-to-face or pre-recorded lectures. Dhawan (2020) cites a reluctance at an institutional level by many to change their traditional pedagogical approach opting for live Zoom lectures over alternative arguably more effective online learning methods.

This paper reviews recent literature and compares that to the authors experience regarding the online learning environment over the last year. A critique of various methods is offered as well as evidence driven suggestions with regard to future opportunities. The conclusion is that it is time to reimagine how education can be delivered incorporating best practice from both worlds.

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Test Driven Development Will Make Your Database Deployments Hassle Free

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Keywords

Test-driven Development, Workshop, TSQLt, T-SQL, Database Development

Abstract

Test-Driven Development (TDD) has a proven track record in application development, but is less ingrained in database development work, despite data quality is increasingly critical in a data-driven economy. This mindset has changed with the arrival of test frameworks that use the SQL language, and that are available as plug-ins for development environments. In this workshop, we will discuss in detail a Unit Testing framework for databases called tSQLt that is available as a plug-in for SQL Server Management Studio. This free open-source library has gained a lot of attention lately; even more so since industry leader Redgate have put their weight behind it by making tSQLt the backbone of their product SQL Test.

We will start by reviewing the way that unit-testing frameworks support some of the TDD practices commonly used by application developers. We will then explain how tSQLt and SQL Test provide those same features for database developers and why they make it so much easier to do effective test-driven development in T-SQL. This presentation will help audiences to get started with running tSQLt tests. It uses a sample project, but the steps are applicable to any database project.

We will conclude our presentation by describing how to run tSQLt tests as part of a Visual Studio Team Services (VSTS) DevOps deployment. This engaging and interactive presentation will be useful for both practitioners and academics alike as it will demonstrate the importance of test-driven database development to ensure data quality in tertiary institutions and beyond.

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Studio in the Bachelor of IT

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Keywords

Studio, PBL, Work-Based Learning, Social Constructivism, Competency-Based

Abstract

1. Introduction

The Bachelor of IT at Otago Polytechnic has included a 45-credit capstone project in the third year and a preparatory Software Engineering course covering Agile techniques for approximately a decade. This Project course was intended to consolidate and practice the skills that learners had developed throughout the technical and soft skill courses making up the rest of the programme, and to prepare learners for the work environment in the IT industry (BIT programme document, 2009).

In about 2018, lecturers on the Project course began to observe a lack of technical and collaborative confidence in many learners which often prevented them from producing any useful contribution to their projects. This prompted some changes in the way Software Engineering was taught in order to try to better prepare learners for the unfamiliar environment of the Project course, which seemed to serve only to extend the problem further back by one semester.

When the BIT came up for review in 2020 the issue of readiness for Project – and therefore readiness for entering the workforce – was a central focus and the proposed approach was to begin coached, scaffolded and carefully curated Project-like learning starting from the first day of the programme. The new series of courses was called “Studio” to distinguish the approach from purely “Project-Based Learning”, although PBL (Kokotsaki, 2016) makes up part of the approach.

2. Aims and Research Design

This research aims to encourage programme developers to consider incorporating Studio-style courses into their own offerings, and to provide some initial guidance as to why and how to do that.

Why is it helpful to supplement proven CS Education methodologies with a contrasting approach? What does this approach look like in the classroom, and how does it compliment the traditional CSEd-style courses in order to produce more work-ready graduates? What have been the challenges and successes so far, and what unexpected things have we learnt?

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This research is conducted using a combination of literature review focusing on pedagogical theory, a Research Diary written by Studio lecturers and observations from teaching staff and industry employers in order to determine the best approach to dual-mode vocational IT training.

3. Analysis and Findings

Studios 1, 3 and 5 have now run for two semesters, and Studios 2, 4 and 6 for a single semester. This places us about half way through our transition plan from the “old” BIT to the new. Now that all Studio courses have been delivered at least once, we are in a position to share our learnings so far.

In-class observations show that learners are buying in to the “simulated work-based learning” environment, especially those who started at Studio 1. Informal feedback suggests that their technical skills are benefiting and that acceptance for the need to learn soft skills has increased because those skills are learnt and applied during technical activities.

The coaching (rather than lecturing) approach has resulted in learners understanding that making mistakes is an acceptable way to learn to make their own decisions, and willingness to trust their own judgement is increasing with these experiences.

Multiple cohorts will need to be observed to judge whether these observations are repeatable.

4. Conclusion and Recommendations

Studio is shaping up to be a success. The intended outcomes have so far been realised despite some initial uncertainty from stakeholders during planning. More time is needed to confirm these initial findings and to allow learnings to be applied and iterative improvements made.

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A Comparative Study on the Effectiveness of Automation Testing Frameworks for Web-Application Testing

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Keywords

Automation Testing, Web-Application Testing, Automation Testing Framework, Data-Driven Framework, Keyword-Driven Framework

Abstract

1. Introduction

In today's software development context, customers have high demands for software products. They also require complex business logic being included in the new product. Consequently, the complexity of the business requirements puts much pressure on the software testing team. Meanwhile, customers required to deliver the product at a tight time with high quality (Hanna et al., 2018). Manual testing is not suitable for an important and complex product in terms of time and human resources. The complexity of modern software development amplifies the need for automated testing because automated testing can solve the manual testing issue by minimizing the testing time while maximizing the testing efficiency. Much research has been conducted on different automation frameworks. Most of their studies have evaluated traditional testing against automation frameworks, but few studies rarely assess two different automation frameworks.

2. Aims and Research Design

The purpose of this research is to evaluate the efficiency of web-application testing using a Keyword-driven testing framework against a Data-driven framework. The research focuses on applying two automation frameworks to test a web-application and studying the efficiency of the frameworks.

Research questions: Which framework works more efficiently in the testing of the examined e-commerce web applications?

The design science approach is adapted to perform this research study. The rationale of deciding this methodology is that the methodology includes a research practice to develop an artifact to resolve the identified problem, evaluate the results, and demonstrate the findings to the audience (Peffers et al., 2008). Design science is a problem-solving model originating from artificial sciences, and it aims at creating “innovations that define the ideas, practices, technical capabilities, and products through

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which the analysis, design, implementation, management, and use of information systems can be effectively and efficiently accomplished" (Hevner et al. 2004).

3. Analysis and Findings

Testing e-commerce web application, this work-in-progress study evaluates the Keyword-driven framework against the Data-driven framework in order to identify the efficiency of the frameworks in the web application automation testing. Criteria are based on different scenarios, such as ease of use, performance, script language requirement, adaptability and design time.

4. Conclusion and Recommendations

A designed test automation framework contributes to the testing community and research community as a web testing practice for automation testing. The research records the influencing factors to the frameworks based on the website context during the framework implementation. The experiments highlight the appropriate framework for testing an e-commerce web application.

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Mental Health Disorders Among Dementia People: How Can Technology Support in Their Well-Being

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Keywords

Dementia, Technology-assisted Living, Emotional Wellness, Care and Support

Abstract

1. Introduction

Dementia is an important community issue in New Zealand with some 70,000 people living with the disorder, costing $4.6 billion in care annually (Meng-Lee, 2021). However, the true cost of informal support is not understood as sufferers are heavily reliant on support from their Whānau, friends, neighbours and voluntary community groups in order to continue to live in their own homes. Sir Richard Faull, a neuroscientist with the Centre for Brain Research in NZ recently stated that care must “support the person with the challenge in a way that gives them full value of their life, every day”. Technology can contribute towards strengthening community bonding for people living with dementia. There is an opportunity to harness high on-demand technologies such as Internet of Things, machine-learning, Cloud computing and data analytics to build effective and efficient solutions that will enable dementia patients to retain independence as long as possible. Evidence shows that the home is the best place for such patients as it is the least distressing environment.

2. Aims and Research Design

Digital technology can already predict and diagnose mental health disorders early, based on behavioural patterns of patients. The aims of this paper are to (a) summarise key areas of technology development in supporting patients with dementia, and (b) to identify future directions and implications for how technology-enabled solutions can better enhance wellness and normal living. The research is designed to investigate a technology-oriented perspective for the mental health of dementia patients in conjunction with community-based networks of informal caregivers and formal caregivers. The work will adapt to the design science research approach.

3. Analysis and Findings

AI, big data and biofeedback functionality in the form of wearable detection devices, smartphone apps and in-home safety devices effectively assist with day-to-day physical care and safety monitoring, providing faster response and assistance. Less is known about how digital technology can improve mental wellness and provide support for

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dementia people to continue living meaningful lives. We have created a table that gives a brief synthesis of many salient mental health aspects of wellness and normal living, along with an outline of the main limitations of current technology-oriented support (e.g., Amazon Echo, Google Home, and others) provided to dementia patients.

4. Conclusion and Recommendations

An opportunity exists to apply emerging technologies to design innovative solutions for wellness and normal living that deliver personalised, highly-tailored experiences. Our future work will investigate and build a technological network linking dementia patients, local community bodies, formal and informal caregivers, extended Whānau and District Health Boards. If executed successfully the outcomes of this research can form part of a sustainable medical emergency framework.

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Decolonising Computing Education

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Keywords

Ethnography, Decolonisation, Māori

Abstract

If computing education is going to positively contribute to the future of New Zealand, it needs to come to terms with its responsibility in decolonisation. But there are poorly understood tensions between computing as a coloniser and computing as an enabler of change - and the same could be said for education. While there has been some discussion in international indigenous literatures, there has been little written in an Aotearoa context. In this paper we consider the first role of computing as a colonising and decolonising force, and then add computing education to this framework. We use a fictional ethnography, telling stories of The Boy - a fictionalised rangatahi from a rural Bay of Plenty community. His challenges and opportunities, along with the failings of the system, bring light to questions of the role of computing education in making or breaking his future. This research will provide the impetus for change for computing educators to make a conscious choice in design of education and in dealings with young people and their futures such that computing education is a positive force in decolonisation.

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Is Web Application Security Really Important to You?

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Keywords

Risk and Vulnerabilities in Web Applications, Shift Security Left of SDLC, Vulnerability Assessment, Day Zero Testing

Abstract

• Is Web Application Security Really Important to You?

• Would you like to wait and become a victim of cyberattack?

• Can you protect something that you do not know will be attacked?

• Can I keep pace on ever increasing risks from vulnerabilities?

Web applications today are evolved in terms of their functionality, user experience, and complexity. Web applications are considered as the face of organizations to connect with customers to provide sales and service. Today, you complete everything from your grocery shopping to school assignments via the Internet. If you manage an organization, your website serves as front door and as primary brand identity to customers who shop online. Organizations have paid a lot of attention and secured data entry points at network layer. Web application layer security has taken a fall back and emerged as the stepchild of the entire security posture. If your website is not safe or secure, the situation can create obstructions to business relations and damage your brand value. In simple terms, web application and services are under constant siege for potential data breaches.

In 2015, Gartner reported that '75% of cyber-attacks and Internet security violations are generated through Internet applications.' In March 2020, after the COVID-19 Wuhan 'Corona Virus' pandemic outbreak saw an increase of cyber-attacks by 350% increase in first month. You see the increase in percentage by 5 times in 5 years and such attacks will continue to rise.

Even if you think your business is too small to be targeted or have anything valuable on your website, it does not make you an exception. Hackers use automated tools to detect vulnerable sites/applications and do not discriminate when it comes to their targets. Their primary motivation is to pilfer personal information and/or your money, with the least possible work on their end.

Application security testing is the most vital security practice websites need to fix all their potential loopholes to evade any kind of cyber-attacks. The simple solution is that you need to incorporate application security testing into your Software Development Lifecycle (SDLC). It is also called as Shift 'S' left for S-SDLC.

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Application Testing in the Agile (CI/CD) World

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Keywords

Agile Testing, Vulnerability Assessment, Automation Testing, Day Zero Testing, Shift Left Testing in SDLC, Quality Assurance

Abstract

Ways and means of application testing have changed over the decades. I have seen how dedicated QA born for quality checks, how need of automation came to existence. The manual testing was taken over by automation testing to reduce the turnaround of the testing time for repetitive tests thus reducing effort anywhere from 2 weeks to 2 days. It supported the repeated tests thus reducing the dependency on the need for multiple manual testers. However, over the last few years with the advent of agile development, automation testing has become difficult for managers to manage.

Now bots are supporting, helping, and slowly taking over QA (Quality Assurance). QE (Quality Engineering) is going to be the key.

Does that mean there is no Future for Manual Testers?

Manual Testers vs Automation testers, performance test engineers and vulnerability assessments

Description

• To perform automation testing, there is a need for skilled developers writing the test scripts from the manual test cases.

• To conduct performance testing, there is a need for skilled performance test engineers to write performance test scripts.

• To conduct cross browser testing, there is a need of tools and skills to configure and develop cross browser testing.

• To conduct vulnerability assessment, there is a need for a niche security testing skills.

All the above adds to the costs in the agile development. It also adds to effort which is difficult to manage when every two weeks new features are delivered.

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Key Take Away:

Using Shift left or a day Zero testing without Automation tester, performance, or security.

A BA and/or manual tester should be able to perform automation testing, performance testing and also vulnerability assessment. Can contribute QE from sprint zero without writing a single line of code.

Does that mean we can reduce the dependency on skilled resource and costs in Automation testers, performance tester and security consultants in agile development? Absolutely!

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Towards Mitigating Privacy Concerns in Camera-Based Fall Detection Techniques

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Keywords

Fall Detection, Identity Hiding, Privacy, Context-Based

Abstract

1. Introduction

Elderly and some physically challenged people require continuous attention and care due to their physical and health conditions. Significant proportion of these people are prone to fall-based critical injuries ranging from minor to fatal (Zhang et al., 2015). The definition of a fall is an event that results in a person coming to rest unintentionally and abruptly on the ground or other low surfaces (Pannurat et al., 2017). The World Health Organization (WHO) stated that about 646,000 fatal falls happen each year across the world and most of the sufferers are more than 65 years old (World Health Organization, 2018). Moreover, globally there is a significant shortage of caregivers to take care of the growing ageing population and it's no different in New Zealand. Technology has come to the aid and multiple sensory and artificial intelligence (AI)-based techniques for automatic fall detection and warning system have been proposed by the research fraternity as part of the ambient-assisted living.

The different technology-based fall detection techniques can be categorized into various categories (Fig.1). Most of these either need sensors or equipment that can work with radio frequency or can be connected to through WiFi or cellular connections. For instance, context-based fall detection uses equipment like surveillance cameras and efficient and low-cost computer vision techniques to detect falls. These indoor security cameras do not affect the day to day privacy of users.

A primary concern for users, however, are most of these technology-based fall detection systems now are cloud-based and have online connectivity, which make them vulnerable to data privacy issue. Lot of these fall monitoring and detection systems rely on AI techniques.

2. Aims and Research Design

This ongoing research aims to explore the possible solutions to mitigate privacy concerns in context-based fall detection techniques. With surveillance camera images, users are primarily concerned about revealing the: (a) identity of an individual (e.g., facial features, appearance, cultural identities and other visible features), and the (b)

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environment that implies the surroundings (location, landmarks around, personal interests etc.), based on which users in the image can be identified and tracked. Identity of individual(s) and / or objects in the images can be removed through the application of image filters, encryption, de-identification (like deepfake), image inpainting and visual abstraction. Figure 2 shows the key implementation stages of this ongoing research.

3. Initial Results

Initial experiments using machine learning (ML)-based filtering algorithms have shown promising results in identity removal. Figure 3(a) illustrates the removal of facial features of the individual, whereas Figure 3(b) shows the result of distinct parameter-based filtering technique. While the first image only blurs the faces of the individual, it does not change the background and thus reveals few environmental identities, like, location, objects, etc. The second one, on the other hand, alters the entire effect of the images by changing image parameters, such as, mode, color and threshold. Thus, most of the identities appear to be protected in the images. In some cases, only the image silhouette is displayed.

4. Conclusion and Recommendations

The privacy concerns for camera-based images, particularly for common incidents, like fall, need immediate attention. Preliminary investigation provides a clear feasibility of applying ML-based algorithms for identity removal from context-based fall detection environment. Although, there exist well defined algorithms both for identify removal and fall detection, it is always challenging to combine them together.

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IT Educators Beyond COVID- One Year On

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Keywords

COVID-19, Remote Teaching, Emergency Remote, Pastoral Care, Relationships

Abstract

At CITRENZ 2020 we described the experiences of teaching computing education during the Global COVID-19 pandemic. Tertiary IT educators shared their experiences and approaches through prepared narratives of their teaching experiences and responded to a set of prompts designed to elicit reflection on themes including drivers, opportunities and challenges. Three themes emerged from the narratives presented - tailoring engagement, pastoral care, and learning for the next disruption. In this current paper we focus on those changes that have stuck - that have become embedded in practice. We describe a collective reflective process of exploring the themes and practices one year on from the initial disruption and ask “what has stuck?” And what has continued to change as the global pandemic continues to disrupt normal patterns of life and teaching? Last year we concluded that there needs to be a focus on maintaining a positive approach to learning, even improved outcomes in some instances. We asked the question “how can we translate this positive approach into everyday practice so that relatively minor upsets that might otherwise derail someone’s learning and career can be seen as learning opportunities?” and we revisit this question with more reflection from the lived experience of our educators.

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Why Don’t Girls Study IT? Redressing The Gender Imbalance in The Information Technology Sector

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Keywords

Disproportionate Representation, Gender, Women, Gender Imbalance, Women in IT, STEM

Abstract

In Ara’s Bachelor of Information and Communication Technology (BICT) there is a strong gender imbalance in 2021 new student enrolments (15% female) that reflects the imbalance shown in the IT industry and in other tertiary learning institutions. Studies have shown both that this imbalance is stronger in IT than it is in other male-dominated STEM areas, and that a major contributing factor is the perceived stereotype of IT being for ‘geeky male loners’ that is prevalent in society and in popular culture. This stereotype affects girls’ choice of topics they choose at high school and as a future career. They do not envision themselves in a role in which they don’t see people who are like themselves. This means that women are missing out on potentially lucrative and valued careers, and the industry is not getting imbued with the perspective of half their client and user base. A review of the current literature is presented with the view of forming the basis of a survey to be conducted using current and past students of the department to enable their perspectives to be analysed. Future work will be to investigate how high school-age girls relate to the idea of taking IT as career with the aim of removing the barriers to taking that path, and therefore increasing female enrolment in Information Technology programmes.

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A Proof-Of-Concept Study of a System for Querying Homomorphically Encrypted Educational Data

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Keywords

Homomorphic Encryption, Security, Microsoft SEAL, Querying, Storage

Abstract

New Zealand has had one of the highest dropout rates in high school and lowest reporting in higher education than its counterparts in the developed world (Scott, n.d.). The numbers have improved slightly in recent years, but it is still a matter of concern. To find the cause of why it is happening and preventing it from happening is very important so that the socio and economic development of the individuals and the country can be increased and sustain for a long time. Currently in New Zealand, there are 16 polytechnics in which more than 130,000 students are undertaking various courses ranging from Level 4 to Level 8 or more. (Tertiary Participation, n.d.). It would require a lot of resources and inputs from various organizations that must be collected and analysed in a systematic order to find out the reason behind what has been happening and intervene it at early stages so that the cycle of dropouts can be prevented. Not only the drop-out rates but several other useful results can be obtained by analysing the information.

Storing all that information in various places and trying to work with multiple organizations at the same time can be very challenging and if all the information is kept under one roof, the privacy aspect of the data can jeopardize the purpose of the work it is intended to do. Millions of users in various organizations had their data stolen by various attacks and it is reported more than 600 million user's data has been stolen either completely or partially from organizations, for example Adobe, Marriott International, LinkedIn and so on. The cost for the organizations to solve such data breaches has skyrocketed to more 3.2 billion pre-COVID, let alone the during pandemic attack it is considered as the global cyber security threat (Swinhoe, 2021). With so much in stake we are aiming at understanding the strategies that can mitigate such security threats and thus enhance the level of security.

Homomorphic encryption (HE) (Yi X., 2014) can serve the purpose of collating the data under one roof and at the same time it can also ensure that the security is the priority, and the data is not going to be accessed only by the person who is intended to. With HE, encrypted data can be processed for results without decrypting it or revealing the original data. There are several fully homomorphic encryption schemes that allows meaningful computations on encrypted data (Yousuf H., 2021).

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The aim of this research is to study the feasibility of a system where encrypted student information from various institutions can be stored and queried for meaningful results while protecting privacy of the students. We are looking to investigate,

- queries and usefulness of results that can be performed/obtained on homomorphically encrypted student information.

- feasibility of performing queries on centralised and distributed encrypted storage using multi-party computation protocols (Cramer R., 2005) (David Evans, 2018)

At the early stages of the research, we are building a prototype by taking WelTec students' information and processing it in a local database storage location. Using Microsoft SEAL (Microsoft SEAL, n.d.), HElib and/or TFHE, queries will be injected into the system to see how and what queries can be processed and to analyse and verify if the results are accurate. As the work is in progress, the limitations of the research at this moment in time are mainly the procurement of number of resources, homomorphic encryption does take the processing of the data too long than the other conventional methods. The time to process the instructions to conduct the feasibility test can also vary depending upon the size of the dataset we are working on. Once the initial data set works with all the queries, we can increase the number of storage nodes and analyse latency. We would like to present the work done and the initial results at the conference.

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Reviewing Use of Collaboration and Video Conferencing Software on The Timaru Campus of Ara Institute of Canterbury

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Keywords

Software Technology, Video Conference, Collaboration Software

Abstract

Mergers, amalgamations – Te Pukenga, COVID-19, and changing nature of the workplace have led to a high number of options of different types of software for collaboration, video conferencing, enterprise communication and document sharing being provided and used in educational organisations. Software is required to connect classes online across campuses, engage in meetings between different locations, share information between colleagues and collaborate across the organisation.

The impetus for this paper is to investigate what is being provided and to determine whether the software being provided across the organisation is fully utilised at the Timaru campus of ARA. This paper will also explore whether staff understand the role of the different options provided across the organisation. The software included in this paper are Zoom, Teams, Yammer, OneNote, OneDrive, and normal use of emails.

This information will be of interest to educational organisations as there might be duplication of software functionality and confusion about the need to use the different types of software. This will be clarified and explored in this paper.

Conclusions include the willingness of lecturers to explore new technologies and adapt to new environments if the need and benefits of doing so are understood. Lecturers focus on the needs of the student and want to utilise all possible options to ensure that the students succeed. Collaboration and sharing among the lecturers are an important part of this.

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Selection and Adoption of Tools for Analytics and Business Intelligence: An Exploratory Study

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Keywords

Business Intelligence Tools, Analytics Tools, Functional Factors, Non-Functional Factors, Business Analysts, Data Analysts

Abstract

In the modern business environment, business intelligence plays an essential role in improving companies' competitiveness by implementing predictive analysis. This has resulted in an increased number of organisations that have selected and implemented advanced software solutions, with the aim of more effectively managing workloads, increasing profitability and maintaining competitiveness.

The purpose of this paper is to examine and determine the main functional and non-functional factors used in the selection and adoption for business intelligence and analytics tools, with this including an analysis of the types of business intelligence and analytics tools that are widely used by New Zealand's business and/or data analysts.

A Qualtrics survey was distributed to data and business analysts in New Zealand and Australia via LinkedIn with 46 respondents completing the survey. The results were analysed using a number of Mann-Whitney tests in SPSS.

The results demonstrate that both functional and non-functional factors are essential when analysts select and adopt business intelligence and/or analytics tools. Moreover, in terms of functional factors, the most critical factors of functional factors are data visualisation, data cleansing and preparation, extracting, transforming and loading, and the most important non-functional factors are ease of use, reliability, and scalability. Microsoft Excel, Microsoft Power BI and, Python were the most widely used tools by the respondents which the percentage of usage being above 50%.

This research has implications for the selection of business intelligence and data analytics tools, particularly in relation to the importance of functional and non-functional factors when it comes to establishing criteria for the selection process.

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The Landscape of Computing: Benchmarking ITP Computing Degrees

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Keywords

Computing Curricula, IT Education, Global Computing Education, Benchmarking ITP Degrees

Abstract

In March 2021 the ACM/IEEE-CS Computing Curricula 2020 (CC2020) report was published [1]. This report covers all the areas of computing and is global in its attention. The report looks at and analyses the six discipline areas of computing that currently have ACM and IEEE-CS approved curricula: Computer Engineering, Computer Science, Software Engineering, Information Systems, Information Technology and Cyber Security [1]. The report does not yet include Data Science as that new curriculum is still under development.

A clear difference exists between the computing disciplines and that they all have distinguishing characteristics that are essential for their individual identities. Traditionally these areas had their own degrees and were taught in universities globally. The Institutes of Technology and Polytechnics (ITP's) were approved to teach degree programmes in the early 1990's and computing was one of the first subject areas to offer degree programmes. Due to the nature of the close alliance of industry with ITP qualifications the ITP degrees reflected the needs of industry with the underpinning theory required, hence they were much more multidisciplinary that the traditional computing degrees.

The CC2020 Steering Committee analysed all the approved curricula in the six discipline areas and looked for any overlaps. For example, all the areas have some aspect of programming but not all at the same level. A Landscape of Computing table was then developed with six main topic area which include 34 subsections. Each computing discipline specifies a minimum and maximum value suggesting an importance range within which most degree programs are likely to fall. This table was then further developed to include the minimum and maximum values required for each discipline level [2].

This table is of significant relevance to the ITP computing sector in New Zealand. It can be used to visualise the ITP computing degrees and where there is more or less relevance to the degree programme, the local industry and the national interests as a whole.

This quality assured paper appeared at the 12th Annual Conference of Computing and Information Technology Research and Education New Zealand (CITRENZ 2021) & 34th Annual Conference of the National Advisory Committee on Computing Qualifications, Wellington, July 14-16, alongside ITx 2021.

The CC2020 project also developed online visualisations of the knowledge areas, where stakeholders can assess a degree program with the values required and then match it against any of the current approved curricula.

This paper will describe the development of the Landscape of Computing table, it's significance and relevance to the ITP sector current degrees and any future updates that are envisaged.

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Investigating Social VR-based Student Presentations

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Keywords

Virtual Reality, Social VR, Education, Remote Learning, Social Presence

Abstract

1. Introduction

Researchers have explored the application and benefits of Virtual Reality (VR) for education for several years (Radianti et al., 2020). VR technologies are being utilized for teaching and training both in and out of the classroom. Through networked VR, Social VR platforms can provide shared virtual environments for social interaction and collaboration (Matthews et al., 2021). Researchers have investigated the use of Social VR platforms in remote learning contexts for remote lectures (Yoshimura et al., 2020; Hopp, et al., 2020) and virtual student poster sessions (Holt et al., 2020).

Matthews et al. (2021) describe three primary benefits of VR technology: presence, interactivity, and immersion. Presence describes the feeling of “being there”. Interactivity is the ability to modify an environment in real-time. Immersion can be defined as the interplay of presence and interactivity. In a Social VR environment, these qualities can be experienced with others sharing the remote virtual environment.

Video conferencing is a typical solution for remote learning. Zoom is commonly used for remote lectures and workshops. However, researchers have found a number of issues with video conferencing with respect to social interaction and remote presence among participants (Matthews et al., 2021; Yoshimura et al., 2020).

2. Aims and Research Design

Oral presentations are a common assessment method used by teachers. In remote learning environments, presentations can be given over video-conferencing or by pre-recording audio/video with the presentation slides. There is a gap in the research regarding studies of student experiences and attitudes on giving presentations in a social VR environment compared to video conferencing. This research intends to investigate the use of Social VR as an alternative to video conferencing technology for student-led presentations.

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The researchers believe that Social VR may be a more appropriate technology and the following research question: What are the differences in student attitudes toward presenting in a social VR environment compared to video conferencing?

The research design is quasi-experimental and will collect data and analyze the relationship between the platform for delivering student presentations and participants' attitudes and experiences for immersive tendencies, presence, and social presence. For the sample, the target population will be Post-graduate IT students attending the Eastern Institute of Technology (EIT) in Hawkes Bay, New Zealand. The sample size is estimated to be 20 students.

Based on this design, our hypothesis is that students will have favourable attitudes toward presenting in a social VR environment compared to video conferencing.

3. Analysis and Findings

Data will be collected using a cross-sectional survey design based on a questionnaire to capture the participants' opinion on the experience of giving oral presentations via Social VR using the Mozilla Hubs VR platform experienced on an Oculus Quest 2 head mounted display.

The questionnaire will include questions on presence, social engagement, useability and attitude based on prior research (Yoshimura et al., 2020). Participants will give two 5-minute presentations to classmates using VR and Zoom. After giving each presentation, participants will take an online survey.

The analysis of the survey data will follow a correlational design.

4. Conclusion and Recommendations

As the research is work-in-progress, the researchers have not formalised any recommendations or conclusions.

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Panel: “What Computing Programmes and Computing Research Should Look Like to Support Te Pukenga”

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Keywords

Computing Programmes Alignment, Computing Research Alignment, Te Pukenga Objectives

Abstract

The panel (proposed and designed by Dobrila Lopez) will discuss:

Computing programmes:

• The current state of our computing programmes

• The changes needed to align these programmes

- to the Te Pukenga objectives

- to industry needs

• The support needed for these changes

Computing research:

• The current state of research programmes

• New areas that should be researched

• Aligning research to industry needs

• The support needed for these changes

This quality assured paper appeared at the 12th Annual Conference of Computing and Information Technology Research and Education New Zealand (CITRENZ 2021) & 34th Annual Conference of the National Advisory Committee on Computing Qualifications, Wellington, July 14-16, alongside ITx 2021.

Workshop: Gaining Entry into Real Settings with Bridging Design Prototypes

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Keywords

Bridging Design Prototype, Human-Centred Design, Design Thinking, Product Development, Innovation, Inclusive Design, Rapid Prototyping, Experience Prototypes, Student Project

Abstract

The Bridging Design Prototype (BDP) approach aims to strengthen the activity of design in new product development undertaken by individual designers or small organisations with incomplete teams.

A BDP is a rapid functional prototype built with features familiar to a user community and with novel features that a designer incorporates after careful analysis of relevant data. It capitalises on a user community's prior knowledge (i.e., the knowledge a user already has about a situation or an activity) and recognises their context realities. These characteristics bring users into the development process early: users incorporate the prototype into their real activities, while a designer or R&D team employ it for learning about the user community. Early adoption of a concept idea in the form of a rapid functional prototype might lead to socially inclusive products, active community participation, or help in raising early capital for a small enterprise. A user community will only be prepared to incorporate a new product in their context, when through personal experience they qualify such a product as being useful, usable, and desirable.

BDPs must be fully functional rapid prototypes. Experimentation should not require the presence of designers. By functional, it means that users must be able to implement them into real activities. But, BDPs are not necessarily minimum viable products, as the digital or tangible materials with which they are built could have a limited lifespan.

The participants will be walked through six BDP principles. Illustrative cases are drawn from projects undertaken in collaboration with a start-up or a SME.

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Workshop: Using Data Science Tools and Techniques for Creating and Maintaining a Passive Investment Portfolio

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Keywords

Investing, Investment Portfolio, Data Science, Exchange Traded Funds (ETFs), Tools and Techniques, Passive Investing

Abstract

In this workshop, we will explore how data science tools and techniques can be used to build and maintain an ETF-based investment portfolio. You will also understand what are exchange traded funds (ETFs) and what is a passive investment portfolio. Data science techniques such as confidence intervals play an important role when comparing and selecting ETFs that are statistically capable to perform according to the investor's expected returns. Data Science tools also help to track and periodically rebalance the portfolio.

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Workshop: Global Benchmarking and Visualizing of ITP Degree Programs

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Keywords

Computing Education, Landscape of Computing, Visualisation, Global Benchmarking

Abstract

A significant part of the recently published ACM and IEEE-CS report “Computing Curricula 2020: Paradigms for Global Computing Education” was the development of visualisations of any computing degree and the comparison with the ACM and IEEE-CS approved curricula. Currently there are six discipline areas that have approved curricula: Computer Engineering, Computer Science, Software Engineering, Information Systems, Information Technology and Cyber Security. Traditionally computing degrees have been developed within the discipline areas; however the Institute of Technology and Polytechnic (ITP) computing degrees differ from this tradition. When the Certificates and Diplomas in Business Computing were developed in the late 1980’s and early 1990’s, they had a significant industry involvement which meant the qualifications were multi-disciplinary and didn’t meet the traditional model of the six discipline areas. Subsequently the development of degree programs in the ITP sector followed this pattern and again had significant industry involvement and are still multi-disciplinary.

The CC2020 report developed a “Landscape of Computing Knowledge” table with minimum and maximum values for each of the 34 discipline areas. As part of the visualisation project an online application has been developed whereby stakeholders can assign a minimum and maximum value to each of the discipline areas that are required in a degree program and then that program is matched against the current ACM/IEEE-CS approved curricula. This will have significant importance for the educators and other stakeholders of ITP degree programmes.

This workshop will guide participants through the process of assigning a minimum and maximum value to the discipline areas of their own degree programme, then enter them into the application and allow the participants to see where in the landscape of computing their own program fits. It will also allow participant to compare their own programme with any other programme entered into the application. We hope to populate the database with programmes from all over the world over the next few months to ensure a global reach for comparison.

This quality assured paper appeared at the 12th Annual Conference of Computing and Information Technology Research and Education New Zealand (CITRENZ 2021) & 34th Annual Conference of the National Advisory Committee on Computing Qualifications, Wellington, July 14-16, alongside ITx 2021.

Poster papers

Ara Smart Campus Mobile Prototype App

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ABSTRACT

The Smart Campus Initiative is aiming to link students to campus services efficiently. In this paper, we address this issue by developing a prototype mobile app called Smart Campus for Ara students who study at the Madras Street campus in Christchurch. We use MIT App Inventor, TinyDB, Firebase and Lucidchart to develop this app. Eventually, the app realizes functions of showing building details, navigation, notification of adverts, rating places, reporting issues and game playing. Gamification concepts is applied to increases user's engagement. Besides, we identify potentials for further development of the mini game.

Keywords: Smart Campus, Mobile App, Location Based Services, Mobility, Gamification

1.INTRODUCTION

Nowadays, the importance of mobile applications is increasing quickly, and they have been widely utilised in education (Alqahtani and Mohammad, 2015). According to the research conducted by Dobbins and Denton (2017), the use of mobile application has positive impact on assisting students on academic engagement.

The goal of Smart Campus app is to create a worked prototype mobile app for Ara students to rate places, to gain building information, to navigate campus destinations and to report issues. Meanwhile, gamification concept is included to increase user's engagement.

Students will be better supported by this app because Location Based Services (LBS) is applied to improve their mobility under a campus scenario (Torres-Sospedra et al., 2015) and to provide target advertisement based on their location (Petcovici & Stroulia, 2016). It not only allows them to easily gain building information and to direct them to the places, but also allows them to receive notifications of promotions from service providers when users are close to specific places.

Unique for the app is the utilisation of gamification concept in the mini game called Water My Plant to foster students' drive to interact with the app regularly so that they can get notification of nearby services based on their real-time location.

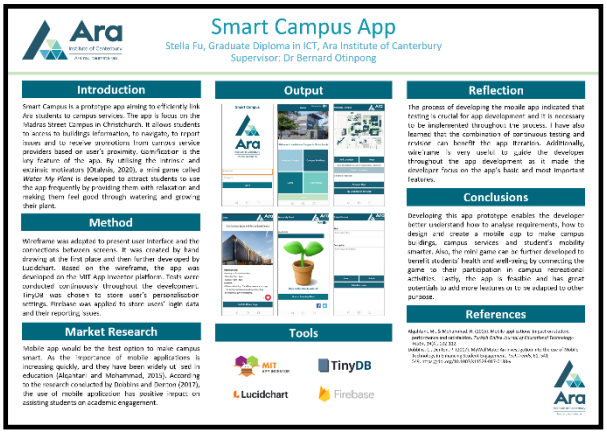

Figure 1 The Poster for Smart Campus App

2.BACKGROUND

The Ara Smart Campus Initiative is aiming to link students to campus services in a more efficient and diligent way, so that barriers could be removed, and relevant users can efficiently access to current and new campus services at anytime.

Particularly, the app is required to comply with Ara name, logo and colours, and to focus on Ara's Madras Street campus in Christchurch. Also, it must allow personalisation. Importantly, the app can only be logged in by entering a valid username and password for the purpose of security.

3.PROCESS

Wireframe was adopted to present user interface and the connections between screens. It was created by hand at the first place and then further developed by Lucidchart.

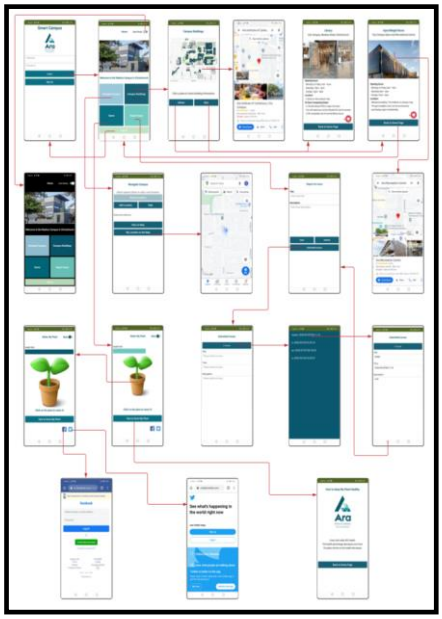

Figure 2 The Wireframe of Smart Campus App

Multiple tools were applied to develop the app:

- Lucidchart
- MIT App Inventor
- TinyDB
- Firebase

Based on the wireframe, the app was implemented on MIT App Inventor platform. User's personalised setting will be stored in TinyDB locally on their mobile devices. For example, the dark mode and mute mode. Firebase was applied to compare users' log-in information and to store their reported issues.

The process of developing the mobile app indicated that testing is crucial for app development and it is necessary to be implemented throughout the process. I have also learned that the combination of continuous testing and revision can benefit the app iteration. For example, the app was revised by adding Ara logo on the upper top corner the of branching screens for branding purpose.

In addition to testing and revision, wireframe is very useful to guide developers throughout the prototype app development because it made the developer focus on the app's basic and most important features at the first place.

Gamification is the key feature of the app. By utilising the mixture of intrinsic and extrinsic motivators (Otalysis, 2020), a mini game called Water My Plant is designed to attract users to use the app frequently by providing them with relaxation and making them feel good or successful through growing plant or keeping it strong.

Particularly, the plant need to be watered regularly to stay healthy (the drive of Ownership and Possession), otherwise the health index will decrease and the plant's size will shrink as the time go (the drive of Scarcity, Loss and Avoidance). Every watering will boost the plant's health index immediately by a simple and timely clicking (the drive of Empowerment of Feedback, Development and Accomplishment). However, watering opportunities will be available after certain seconds, minutes or hours (the drive of Scarcity). Moreover, the game is integrated with social media feature to enable users to share their little green's status with friends on Facebook and Twitter (the drive of Social Influence).

Eventually, users will be more likely to come back to water their plant regularly because of their ownership of the plant, their concern about plant's size and life status, the instant increment of health index and the interaction with friends regarding their plant.

Potentially, the game can be further developed to be more interesting by connecting to the students' health and well-being. For example, students can earn more health index by participating in the activities of campus recreational centre. To match the game design, events and sports features can be added to the home page of the app. Moreover, the little plant could grow up to a tree, and students could collect trees to build their own backyard. Meanwhile, the plant could die if users have not water it for a certain time.

Apart from the gamification and social media features, geo-location and cloud database features are utilised in the app. Utilising the LBS can make the campus' buildings and students' mobility smarter. Once users come back to check their plant, their real-time location can be identified. Hence, they will have the opportunities to get notification of promotions or events from nearby campus service providers if they are use the app's navigation feature to find a place. In real life, users' information about authentication and their reported issues are more likely to be sent to the service provider's cloud or server. Therefore, Firebase is chosen as the cloud database to store these data. To log in the app, users need to enter a valid username and password, these inputs will be verified by comparing with the data stored in the cloud database.

4.CONCLUSION

In conclusion, developing the Smart Campus prototype app enables the developer better understand how to analyse client's requirements, how to design and utilise mobile technologies, to create a mobile app to make campus buildings, campus services and student's mobility more intelligent. Ara students can be better supported by this app because they can efficiently access to the campus building details, navigate to the destination they want to at anytime, rate spaces and report issues, receive advertisement from campus services based on proximity. More importantly, the app includes a unique mini game called Water My Plant to enhance user engagement. The mini game still has the potential to be further developed through making connection to students' participation in recreational events. Lastly, the prototype app is feasible and has great potential to add more features or to be adapted to other purpose.

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Ara Smart Campus

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ABSTRACT

Ara Smart Campus is an application prototype developed for Ara Institute of Canterbury to be used by its students. It helps students find locations and navigate their way to buildings around the campus. In addition, the app was designed to send messages and targeted promotions at students based on their current location within the campus. The prototype also has a vertically scrolling mini game that integrates with the promotional contents in the app to encourage student engagement. This mobile application prototype aims to help Ara students, especially new students, to cope with their transition to study at Ara.

Keywords: Mobile Development, Android, Wireframing, Mobile App, Gamification

1. INTRODUCTION

Students often have problems and confusions in the first few days or weeks of their study. Some cannot find their way to the buildings they needed to be in. The goal was to create a mobile application that can be accessed by these students, to get a quick help on their simple problems.

It is true that after a few weeks or months of study, students will know their way around campus already and might decide not to use the app anymore. The promotional content feature was also added so that every time a student is within proximity of a store, café, or other areas relevant, the application will notify the student about the current promotions in that area.

The mobile application was also designed with gamification in mind. The app specifically focuses on the left brain (extrinsic) core drives in gamification, which is accomplishment, ownership, and scarcity [1].

The prototype app utilizes these core drives to keep students from using the app and provide them goods and personal achievements for doing so.

Figure 1. Ara Smart Campus Poster Presentation

2. BACKGROUND

The Ara Smart Campus is a mobile application that helps students find their way within the campus. This uses navigation to guide and direct them to their destination. The app integrates Google Maps to do this and the app automatically sends location data to start the navigation process. The app also sends promotional content if the user is within proximity of certain areas within the campus (e.g. café, bookstore) while on their way.

The mini game in the app has a concept of collecting 'cash', which are then converted to 'game points'. These game points can be spent within the promotional contents to buy voucher and give better deals for the students. Spending game points will give them 'voucher point'. These voucher points can then be used to buy goods in the stores within the campus.

The mobile application prototype is relevant to Ara students within the Madras campus. Majority of the target audience are new students or those students who came from other campuses who does not know their way around Ara Madras campus. Furthermore, the app offers them great rewards and souvenirs for continuous use of the app.

3. PROCESS INVOLVED

The Ara Smart Campus app was planned and laid out first with a wireframe (see figure 2) that shows all the screens and where it goes when a button is pressed.

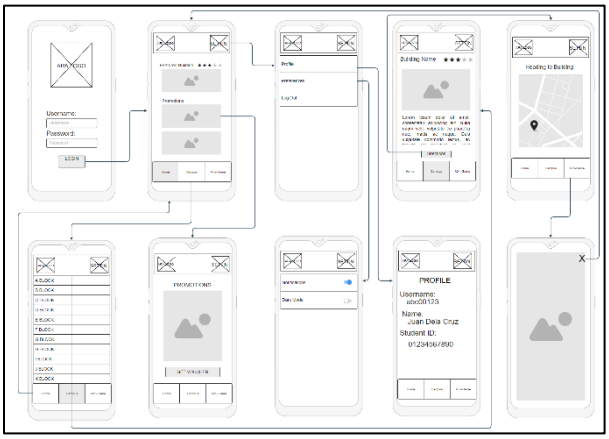

Figure 2. Ara Smart Campus Prototype Wireframe

The tools used to develop the app was MIT App Inventor 2, a cloud-based web application tool for developing android applications. The MIT App Inventor has integration features with TinyDB and Google Firebase. This enabled the app to be used across different android devices and the user can still retrieve its own information and preferences.

The prototype app only used five screens, and instead used layout containers to display different contents. This was done to improve loading performance of the prototype because loading and passing all the data from screen to screen was difficult and there is a high chance of data being inconsistent across the screens.

Unfortunately, navigation feature inside MIT App Inventor 2 is not functioning properly, therefore, Google Maps API was used to fulfil this feature. TinyDB was used to store building coordinates around the campus and their perimeter to enable the app to calculate if the user is within these areas. These also enabled the app to deliver messages or promotional content based on the user's current location.

The app also features a user account system that is stored in Google Firebase. Google Firebase enabled the app to be used by a user across different android devices while retaining the same information on each of them. The way the app handles this is by creating a unique 10-digit ID number when the user creates an account, while also confirming that the account does not exist in the database. Firebase stores all the user account information such as username, name, student ID, preferences, and the like.

The app has also gamification features that rewards the user by using and playing on the mini game feature of the app. The mini game has a score system, which is stored in Google Firebase, which accumulates and can be used to buy vouchers from the promotional contents of the app. When a user spends game points, this requests the current value of game points in Google Firebase, subtracts the amount being spent and storing it back in the cloud. In this way, cheating will be prevented. The user will then earn voucher points every time the user spends its game points. Voucher points can then be spent to get goods and goes through the same process as the game points to avoid cheating. Therefore, the user will then utilize this gamification feature to use the promotions and get the souvenirs that they like.

4. CONCLUSION

The mobile prototype app helped me get an idea of what is the process of developing an app. It also helped me to fulfil requirements to deliver the desired product for a client, Ara Institute of Canterbury, and to make it appealing for the people who will use it, the students.

Finally, this app has a great potential, and it would be excellent if Ara Institute of Canterbury support it so that students, especially new students, will benefit for this smart campus initiative.

5. REFERENCE

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The impact of Covid-19 lockdowns on the learning and teaching of tertiary learners at Wellington Institute of Technology, New Zealand

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ABSTRACT

Covid-19 affected the world in multiple ways, one such being education. This research primarily focusses on tertiary education and how the New-Normal Online learning during Covid-19 impacted tertiary learners. Newer and proactive strategies are essential to build a resilient education system which will ensure uncompromised development of skills required for the future workforce despite alternations to learning methods. The objective of this research is to gain understanding of the learner's experiences and investigate for newer and improvised teaching and learning methods for the future education. This research was conducted using a survey sent to learners in the form of a structural questionnaire. The participant sample included learners studying in levels 5-7 at Wellington Institute of Technology (WelTec). Based on the received responses, this study further investigates and suggests newer or improvised learning and teaching methods for the future.

Keywords: pandemic, Covid-19, New-Normal, Blended learning, Tertiary learner

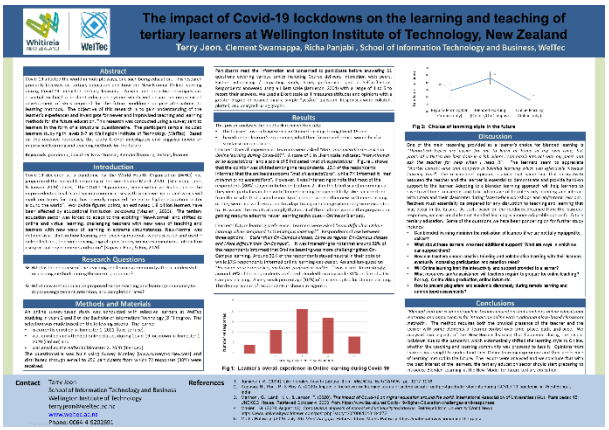
1. INTRODUCTION

Covid-19 declared as a pandemic by the World Health Organisation (WHO) has jeopardized the normal functioning of the world since March 2020. (Marinoni, Land, & Jenson, 2020) states, "The COVID-19 pandemic, which within weeks has led to the unprecedented health and socio-economic crises with which we live in and which will mark our times for long, has severely impacted the entire higher education sector around the world". Worldwide figures points, an estimated 1.8 billion learners have been affected by educational institution lockdowns (Maslen , 2020). The tertiary education sector was forced to adapt to the evolving "New-Normal" and shifted to online and virtual learning, challenging teachers with new ways of teaching and learners with new ways of learning in extreme circumstances. New-Normal was defined as a "shift in how learning and teaching materials were accessed and used – online lectures, teleconferencing, digital open books, online examinations, interaction using virtual environments and so on" (Kapasia, Paul, & Roy, 2020).

2. THE EXTENDED ABSTRACT

Within the New Zealand tertiary educational perspective, it is undeniable that COVID-19, immensely changed the face of education for teachers and learners.

Surveys in Australia (Maths Pathway, 2020) found that most teachers believed, learners coped at only 50-75% of their regular pace while studying from home during the pandemic.



However, the authors of this research strongly believe that if we can understand learners' experience, we can introduce strategic and innovative methods to our teaching and learning practices which will eventually overcome these challenges and thus support better learning in the future. By introducing newer strategies to improve learner engagement and participation we may obtain an increase in retention and completion rates. Two common issues raised are investigated here:

- What is the response of the teaching and learning community after a sudden shift in learning methods during the recent pandemic?
- What new methods can be proposed to the teaching and learning community to improve engagement, retention, and completion rates?

The researchers obtained full approval from the W&W Research and Ethics approval committee before communicating with their participants.

3. METHODS AND MATERIALS

An online survey-based study was conducted with selective learners at WelTec studying in years 2 and 3 of the Bachelor of Information Technology (BIT) degree. The selection was made based on the following criteria. The learner,

- is currently enrolled in Trimester 1, 2021 (face-to-face).
- was enrolled and attended online classes during Covid-19 lockdown in Trimester 1, 2020 (Online) and
- was enrolled thereafter in Trimester 2, 2020 (Blended).

The questionnaire was built using Survey Monkey [www.surveymonkey.com] and distributed through e-mail to 250 participants from which 72 responses (30%) were received. Participants read the information and consented to participate before answering 21 questions covering various topics including Course delivery, Interaction with peers, Factors influencing / impacting study, Study preferences and a Self-reflection. Respondents answered using a Likert scale (Jamieson, 2004) with a range of 1 to 5 to record their answers. We used a Likert scale as it measures attitudes and opinions with a greater degree of nuance than a simple "yes/no" question. Responses were collated, plotted, and analyzed using graphs. Part of the findings are presented in this conference as a poster.

4. RESULTS AND DISCUSSION

This poster analyses the feedback received to study:

- the learner's overall experience in Online learning during Covid-19 and
- based on the learner's experience, what their future preference would be if a similar situation occurs.

Learner's Overall experience: Learners were asked *"Rate your overall experience in Online learning during Covid-19?"*. A score of 1 in Likert scale indicated "*met minimal or no expectations*" and a score of 5 indicated "*met all expectations*". Figure 1 shows that the opinion was divided among the respondents. 13% of the respondents informed that the online classrooms *"met all expectations"*, while 7% informed it *"met minimal or no expectations"*. However, it was interesting to note that most of the respondents (80%) stayed in-between (options 2 - 4 in the Likert scale) informing us they were partially satisfied with Online learning though not fully. We can conclude from the results that a small minority of learners were either new to Online learning or they were not well resourced to adapt to a quick change when they were expected to. However, the results also imply that most of the students were either prepared or getting ready to adapt to newer learning techniques – Online or Blended.

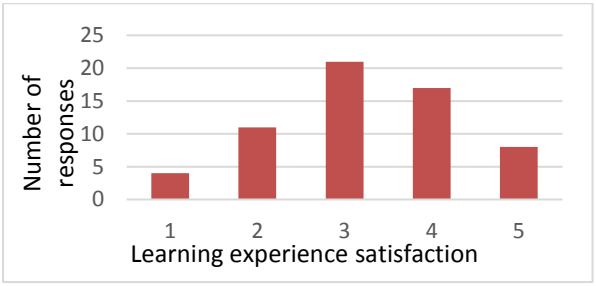


Fig 1: Learner's overall experience in Online learning during Covid-19

Learner's future learning preference: Learners were asked *"How difficult is Online learning when compared to On-Campus learning?"*. Respondents chose between three options – "*Easier than On-Campus classes"*, *"same as regular On-Campus classes" and "more difficult than On-Campus classes"*. It was interesting to note that 52% of the respondents informed that On-line learning was more challenging than On-Campus learning. Around 32% of the respondents stayed neutral in their opinion while 17% respondents informed Online learning was easier. An ancillary question *"Based on your experience, my future preference will be..."* was asked. Interestingly, around 59% of the respondents preferred blended learning while 31% preferred a On-Campus learning. A very weak percentage (10%) of learners opted for Online learning. The demographics of respondents is shown in Figure 2.

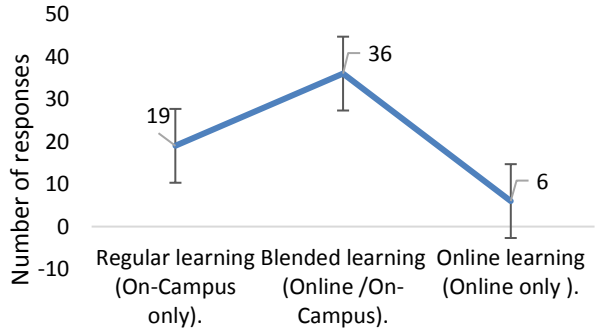


Fig 2: Choice of learning style in the future

One of the main reasons provided as a learner's choice for blended learning is *"Theoretical topics are easier for me to learn at home in my own time, but practical activities are best done in a lab where I can easily interact with my peers and ask the teacher for help when I need it"*. The learners seem to appreciate *"shorter contact time that happens in blended learning which can effectively increase learning time*". The researchers' opinion is along that same line that interactivity between the teacher and the learner is essential to demonstrate and provide hand-on support to the learner. Adapting to a blended learning approach will help learners to save travel time to campus and take advantage of flexible study planning and interact with tutors and their classmates during face-to-face workshops and lab/tutorial sessions.

Teachers must essentially be prepared for any disruption to teaching and learning that may occur in the future. As such, based on the feedback obtained from the learners' responses, we can conclude that Blended learning is a more adaptable option for future tertiary education. Some of the questions we have been pondering on for further study includes:

- Can blended learning diminish the motivation of learners if we are not fully equipped to deliver?
- What about those learners who need additional support? What are ways in which we can support them?
- How can teachers ensure creative thinking and collaborative learning with their learners eventually increasing participation and retention rates?
- Will Online learning limit the interactivity and support provided to a learner?
- What resources and/or assistance will teachers require to prepare for online teaching? For e.g., Online video production, online forum etc.
- How to prevent plagiarism and academic dishonesty during remote learning and unmonitored assessments?

5. CONCLUSION

"Blended learning is an approach in tertiary education that combines online educational materials and opportunities for interaction online with traditional place-based classroom methods". The method requires both the physical presence of the teacher and the learner with some elements of learner control over time, place, path, and pace. We analysed two aspects of the New-Normal learning that happened during the recent lockdown due to the pandemic which automatically shifted the learning style to Online, whether the teaching and learning community was prepared to face it. Opinions from learners was sought to understand their Online learning experience and their preference of learning method in the future. The results were analysed and we conclude that with the best interest of the learners, the tertiary education sector should start preparing to introduce Blended-Learning as the New-Model for future tertiary education.

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Holographic Innovation at Christchurch International Airport

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ABSTRACT

This paper describes a holographic innovation project undertaken in partnership with Christchurch International Airport Ltd (CIAL), Bekon Media and Ara Institute of Canterbury Ltd. This project was to create 3D holographic animations for CIAL to enhance on-site customer engagement with the use of a Dreamoc XL3 HD Holographic display unit. Agile methodology and Design Thinking process had been used to direct the development process. A series of iterative versions of the display were created, tested, and reflected upon, and leaded to a final 3D animated holographic display. This innovative display will attract the attention of both locals and visitors.

Keywords: 3D Holographic Animation, 2D to 3D Media Converting, Design Thinking, Agile

1. INTRODUCTION

Figure 1. Poster

Figure 2. A Dreamoc XL3 HD Holographic display unit

This quality assured paper appeared at the 12th annual conference of Computing and Information Technology Research and Education New Zealand (CITRENZ 2021) and the ITx 2021 Conference, Jul. 14-16.

Christchurch International Airport Limited (CIAL) is the only international airport in Christchurch, and the busiest in the South Island. As the gateway to Christchurch and the South Island to many visitors, the airport is looking to lead innovation.

CIAL has a park to plane strategy – recognising that most customers and consumers interface with the airport on the journey to and from a flight, and it is in this area that they are looking to enhance customer engagement with the use of new technology including a Dreamoc XL3 HD Holographic display unit, as shown in Figure 2, from Bekon Media.

Bekon Media is a Christchurch based digital media and advertising agency, pioneering the use of 3D Holographic displays in New Zealand.

Ara Institute of Canterbury Ltd is a leading tertiary educational institute in Christchurch. This project was undertaken in partnership with the Department of Business and Digital Technologies at Ara, as part of their partnership with CIAL to create leading digital technologies.

As such, much of the project work was with input and advice from CIAL, Bekon Media, and the teaching staff at Ara.

2. PROJECT GOAL

The primary issue was that CIAL staff only had one ‘static’ graphic to display and were unsure how to best engage visitors with the display unit to enrich the customer experience.

Therefore, the goal of this project was to enhance the customer experience at Christchurch International Airport. This was achieved through:

1. Researching the current customer experience – seeing how visitors were interacting with different advertising displays at the airport, alongside the current ‘static’ holographic display
2. Developing additional holographic animations for the CIAL to display

3. PROCESS ADOPTED

Following Agile methodology, the development of this project was split into seven two-week phases – each with defined milestone outcomes. A detailed project plan had been used to track progress against these milestones throughout the project

and adjusted as required. The first phase was dedicated to researching the problem at hand – meeting with the client, and developing a creative brief, whilst the following six phases were dedicated to the rapid production of testable holographic files for use with the display. By working with Agile methodology, approval was able to be sought regularly at the end of each phase, ensuring that the materials produced were of high quality, and were accepted by the client.

The design work that formed a large part of this project had followed the principles of Design Thinking (Interactive Design Foundation, 2019). This is an iterative design process that seeks to understand users and place their needs at the centre of the creative process. In keeping with the principles, a set of personas was developed, with user requirements re-defined at the start of each productive phase. This iterative process fitted within Agile methodology and ensured that during each phase the emphasis was placed on the end user and their needs, with the testing at the result of each phase used to ensure that the client's needs were met.

Figure 3. The final 3D animated holographic display

Following the Design Thinking process a series of iterative versions of the display were created, tested, and reflected upon. Each two-week phase of the project concentrated on the creation and testing of a holographic animation – many of which were edited together as a part of the final 3D animated holographic display as shown in Figure 3.

4. CONCLUSION

The goal of this project was to enhance the visitor experience at Christchurch International Airport. We firmly believe that the implementation of the final display has this effect, providing an engaging and informative display for all visitors. This will also promote the airport as a future thinking, innovative space to visit and work.

This project has proven to be both a great challenge, and a rewarding experience. The quality assurance applied had ensured that the client was happy with the product.

Throughout the project I had to learn new skills and apply existing skills to new situations. Experimenting, researching similar products and refining my ideas led to the development of a streamlined and effective technique for the conversion of two-dimensional media to use in three-dimensional holographic displays. Even if the final product was created to be displayed in a particular holographic display unit, the techniques and methods across a range of emerging technologies, e.g., augmented reality, virtual reality, and all types of reflective holographic displays had been researched and learned. This valuable experience will prepare me for adopting emerging techniques in my future jobs.

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Developing a Mobile Application for Ara's Artworks

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ABSTRACT

Ara Institute of Canterbury has a vast collection of Artworks, which they are attempting to share with students. This is where a mobile application is needed to be built a single place of reference for all the artworks on display. This student focussed application should enable students to learn and explore what artwork is available around them. The application requirements were translated into a wireframe to begin with before a running prototype was created using MIT's App Inventor.

Keywords: Mobile Application, Artwork Filter, Ara Artworks, MIT App Inventor, Wireframe, Artwork Memory Game.

1. INTRODUCTION

The goal of this project is to create a mobile application that will assist Ara's students to discover and learn about art works that surround them at the Madras Campus.

This application will support student discover the artwork around them using the multipurpose filter. The filter originally can split the list of artworks with accompanied information (for example title, artist) into four navigable categories, Artist Name, Title, Date and Location. The date and location options are designed for newer students who may be unaware of the artwork collection at Ara. These two filter options have been split up into predefined options ready for selection. This is ideal for newer students as it is a place to start and without multiple choice options (for example locations) they may have no idea how to spell or where to start looking for the artwork around them. The remaining two filter areas Artist and Artwork name have been given a custom search bar, which is aimed at students who maybe more familiar with the artwork and wish to search a title or artist specifically for a location or more information.

The application has a specific feature that makes it particularly unique. Within the artwork application there is a page dedicated to the 'art challenge'. I got the idea from New Zealand based e-commerce company Mighty Ape, where they offer a chance to win vouchers/ prizes if you share what you bought and tag them on a social media platform (Mighty Ape, 2021). The overall goal being to increase awareness and educate students on Ara's art installations fit with idea of Mighty Ape's well. For example, the art challenge section within the application given users the ability to photograph themselves next to artworks and upload them to their chosen social media to share with others.

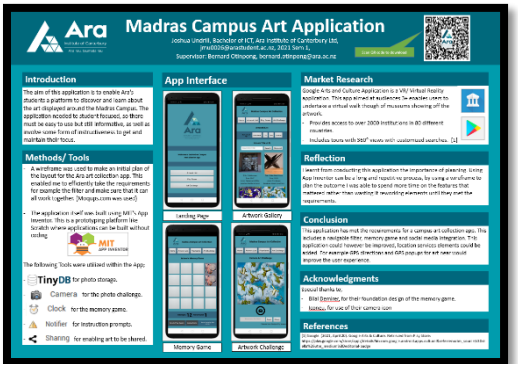

Figure 1: Ara Artwork Application Poster

If Ara decided to follow mighty apes league, they could in the future offer small rewards for randomly shared social media posted with different artworks featured in them. This would act as an incentive to get students searching around Campus for the art they have and sharing their experience with others. This could have a domino effect and hopefully act as a cheap form of advertising and awareness within the student community.

2. BACKGROUND

The Ara artworks initiative is a project within Ara, with an aim of being the first institution to catalogue their vast art collection on a mobile application format. This initiative is aimed directly at students and wishing to establish awareness about what is available. This mobile application is relevant to bridging the gap between Ara's collection and the students themselves. This is because the idea of a mobile application is that it will provide universal tool focussed on students that any of them can use to learn something new about the art/ culture that is on campus.

3. PROCESS INVOLVED

The process of the application began by creating a plan of what the application was going to look like, this was carried out by the creation of a wireframe from the requirements given. This wireframe is shown below as Figure 2.

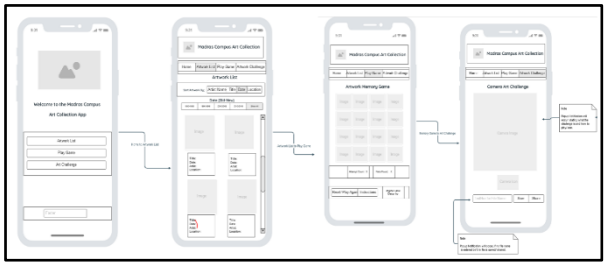

Figure 2: Wireframe for Ara Artwork Application

A prototype of this application was built using the MIT's App inventor. Within MIT's App inventor the following tools were utilized:

- TinyDB (for photo storage of art challenge photo's)
- Camera (for taking photos)
- Clock (for button/ tile effects on the memory game)
- Notifier (for instructions and error prompts)
- Sharing Tool (for social media integration for the photo challenge.)

The artwork application was revised after the initial wireframe/ prototype to add more detail to the filter. Originally the filter buttons only were able to sort one predefined result for each field (date, location, title, artist). This was not suitable in a practical context because it had no flexibility for the user. For example, they were unable to find (search) a specific title or artist or could not see artworks from one location in general. A zoom ability was also added to the artwork collection gallery, where students can click on a photo to enlarge it. This is an essential element of my application because depending on the student's phone size, they may have issues seeing the artwork in the first place. If a student cannot see the artwork properly then they are not as likely to continue to use the application or explore the artworks available and therefore learn about them.

This application being student focussed meant that social media integration was an important element, given the target audience. I decided to incorporate the social media element into the art challenge section, because as I have mentioned in my introduction, it presents an opportunity/ incentive for students to find and share the artwork available around them, maybe even learning something while they go about it.

Creating an application using MIT's app inventor can be a very time-consuming process. This has stressed the importance of planning in terms of mobile development. I have also learnt the foundations around what exactly goes into building a prototype application. Specifically, how to use MIT's app inventor, building an interface (design elements), making it user friendly, and bug free along with building the back end drag and drop coding behind it all.

4. CONCULSION

These application planning and prototyping activities assisted me to achieve the course learning objective of "Analyse emerging and current mobile technologies and their role in delivering outcomes of value." Throughout the prototyping/ planning phase I learnt specific features that mobile applications can have as well as experimenting their implementation. For example, this included gamification, social media elements, cloud storage, and elements of IoT (Internet of Things) such as location services.

These application planning and prototyping activities assisted me to achieve the course learning objective to "Demonstrate a feasibility analysis of a proposed solution". Once I had completed my initial wireframe, and with a little previous experience in MIT's App Inventor, I was able to decide as to whether it was going to be possible to implement. A few issues were encountered because of the initial feasibility analysis (due to limitations in the software functionality), but in the end I was able to find other means of getting the required output.

This mobile application can successfully meet the requirements given by Ara. For example, it has an excellent filter for both new and experienced users, social media integration, with the potential for a reward/ incentive to be attached by Ara themselves, accompanied with a fun memory game which aims to help familiarize the artwork pictures themselves. The basis of this mobile application is that it is a gallery, so this could easily be repurposed to showcase almost anything for any organization. For example, in terms of Ara this application could be repurposed to build a mobile library catalogue of books available to students.

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A Model for Designing Instructional Resources for Teaching MS Project Across Several Courses

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ABSTRACT

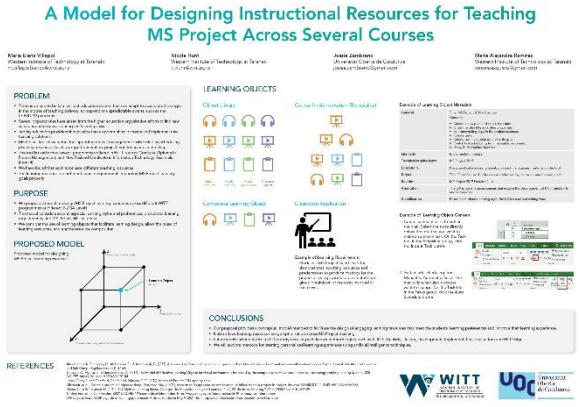
COVID-2019 has caused some learning disruption in New Zealand. Western Institute of Technology at Taranaki (WITT) is seeking new ways of supporting learning to address the future of tertiary education. In alignment with those institutional endeavours, tutors are looking to generate learning resources that better support online and blended teaching. MS Project is a project management tool, which is used across several programmes. Existing instructional resources do not facilitate MS Project learning properly. We propose a three-dimensional model to design MS Project learning resources across different WITT programmes. It leverages learning objects for reusability and composition and for producing engaging learning experiences based on students' learning preferences.

Keywords: MS Project, learning objects, learning resources, student's learning preferences, composite, reusability

1. INTRODUCTION

COVID-19 has impacted the education sector in several ways (Tertiary Education Commission, 2021). Therefore, tertiary education providers have had to find innovative teaching approaches, including those based on distance and blended learning to manage the changing learning environment.

Currently, there is a need to build a resilient education system that can adapt to accelerated changes in the modes of teaching delivery, to respond to unpredictable events, such as the COVID-19 pandemic. On the other hand, several opportunities have arisen from the higher education organisation efforts to find new solutions and proposals during the learning crisis. Tertiary education providers should seize these opportunities to create and implement new teaching solutions.



This quality assured paper appeared at the 12th Annual Conference of Computing and Information Technology Research and Education New Zealand (CITRENZ 2021) in Wellington, July 14-16 2021, alongside the ITx 2021 Innovation Days.

As a consequence of the abovementioned situation and efforts, WITT is seeking new ways of supporting learning and producing a set of solutions to address the future of tertiary education in New Zealand. In alignment with those institutional endeavours, tutors are looking to bring about some learning resources that better support online and blended teaching.

MS Project is a software tool for supporting project management tasks including scheduling, planning, resource allocation, report generation, project monitoring and controlling. The tool is used across several programmes offered in WITT, such as Graduate Diploma in Project Management, and New Zealand Certificate in Information Technology Essentials (Level 4). The students are expected to gain some skills and knowledge in the use of the software according to the learning outcomes specified in each course descriptor. We have found that each tutor uses different teaching resources (e.g., books (Lewis et. al, 2019)), videos available on YouTube, and MS Project blog (Microsoft, n.d.)). If the tutor chooses to employ a book, the students need to buy it because there are not enough copies available in the library. Online support is incomplete; for example, Microsoft Project blog does not include examples. Although there are several videos available on YouTube; the examples used are not always available for the students to try during the class. In general, the learning materials do not meet course requirements regarding MS Project learning goals properly.

Proper teaching resources which can also be accessed online are needed to implement a blended teaching mode as well as to support any self-directed learning as specified in the course descriptors.

In this work, we propose a model to design MS Project learning resources across different WITT programmes at different NZQA Levels. The model considers several aspects: learning styles and preferences (e.g., visual, auditive), prescribed learning requirements, and MS Project skill set areas. We also consider the use of learning objects that facilitate learning

design, allow the reuse of learning resources, and enable resource composition.

2. PROPOSED MODEL

We proposed a three-dimensional model for designing MS project learning resources (see Fig. 1). The model considers the following dimensions: student's learning resource preference, learning requirements, and MS Project skill set areas.

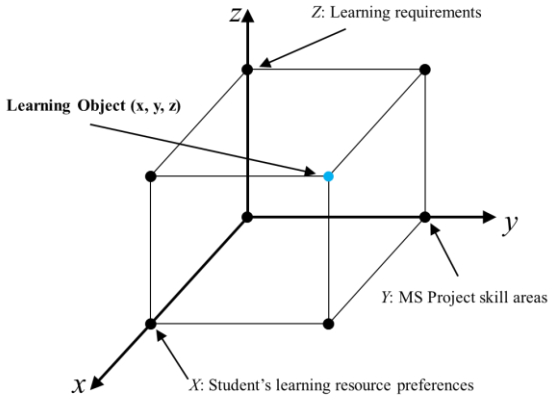


Fig. 1: Proposed model for designing MS Project learning resources.

- The *student's learning resource preferences* can be analysed using VAK's Method which defines the following learning styles: Visual, Aural, Read/Write, and Kinaesthetic (VARK Learn, n.d.). Although the model has been widely used, the ideas are widely debated (Riener & Willingham, 2010). In this dimension, students should be able to choose the audio-visual resources based on their interests; for example, a student can select a video to learn how to create a Project Plan.
- Some of *learning requirements* related to MS Project are stipulated in the course descriptors and course outlines. However, in some courses, MS Project can be used as an alternative tool for managing a project. In this dimension, the desired skills and knowledge are outlined. For example, according to the course descriptor of Project Management, on successful completion, the student will be able to use MS Project to generate a Gantt chart.
- *MS Project skill areas* are the MS Project skill sets, such as starting with MS Project, scheduling techniques, and track project progress. They can be defined from existing Project resources (e.g., (Lewis et. al, 2019) and (Microsoft, n.d.)).

For example, a student undertaking the Project Management course needs to demonstrate the use of MS Project to generate a Gantt Chart, which is part of a basic project scheduling skill set. The learner prefers to use a video learning resource.

3. LEARNING OBJECTS

The realization of the model is the learning objects (LOs) represented as connecting dots in Fig 1. There is not a unique definition of LO. Guevara et. al (2017) provide the following definition: "LO will be considered a reusable multimedia digital resource, which can be used in learning, and employ metadata for description. " The concept emphasizes in two important aspects of our model: a digital resource which has some multimedia features and metadata information required for learning object reuse and composition, which means that several learning objects can be composited to create a more complex resource (Fig. 2).

Fig 2 shows a composite LO that has been generated from four LOs: input a resource, apply costing, apply predecessors, and create report. It will support a learning requirement related to produce a MS Project Gantt chart that demonstrates task relationships and resource assignments to produce the project budget and cash flow report.

Each LO including the composite LO can be reused in several courses to support one or more learning requirements.

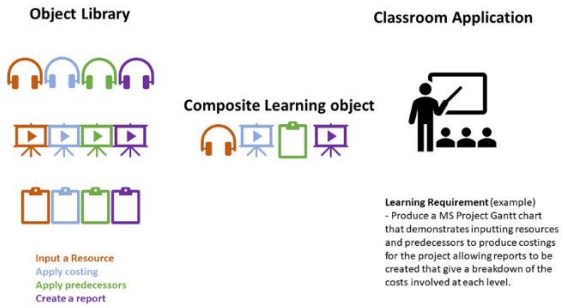


Fig. 2: Example of a MS Project composite LO.

4. CONCLUSIONS

In this research work, we have proposed a three-dimensional model for designed instructional resources for teaching MS Project, which uses the concept of learning objects (LOs) for reusability and composition. Our proposal provides a conceptual model intended to facilitate the design of engaging learning resources that meet the students' learning preferences and improve their learning experience. It also allows learning resources usage optimisation across the courses.

Future works include to design LO prototypes using well-known methodologies, such as ADDIE (Analysis, Design, Development, Implementation, Evaluation) and UX Design. Additionally, we will explore methods for creating personalised learning experiences using artificial intelligence techniques (Almohammadi, et. Al., 2017).

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Acoustic Features of Dysphonic Speech vs Normal Speech in New Zealand English Speakers

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ABSTRACT

This poster presents the acoustic features of distorted speech in three dysphonic New Zealanders compared to three healthy individuals as the control group. There are a total of six subjects in this study. Voice onset time and measurements of the two formant frequencies of vowel articulation in /hVd/ words are calculated for both groups, and the results are provided for comparison purposes. Furthermore, independent sample t-tests are conducted between dysphonic and normal speech results to evaluate the significancy of the differences in acoustic measurements.

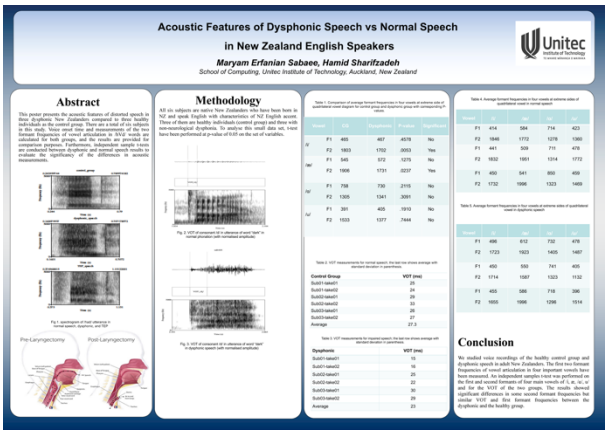
Keywords: Acoustic features, formants, distorted speech, dysphonia.

1. INTRODUCTION

In normal speech, voiced phonemes are generated through periodic vibration of vocal folds, which produces glottal harmonic airflow into the different chambers of the upper vocal tract. The utterance is initiated by exhalation, which induces a stream of air through the trachea and larynx, exiting via the oral and nasal chambers [1].

Some neurological and non-neurological diseases may cause speech impairments. Motor speech disorders (MSDs) are caused by nervous system diseases (neurological in origin). Dysarthria and apraxia are both considered to be kinds of MSDs [2]. Neurological speech impairment is not the focus of this paper.

The non-neurological collapse of speech can be classified into dysphonia and musculoskeletal disorders. Dysphonia can be caused due to various reasons such as inflammation, vocal cord paralysis, vocal nodules and polyps, scarring in vocal cords due to trauma or radiation, and even psychogenic cause such as depression or schizophrenia. Musculoskeletal disorders refer to abnormalities in bone and cartilage in the cleft and palate or any injuries in the musculoskeletal system [3].



Although voice disorders are not usually life-threatening, they have a profound effect on people's day-to-day lives. Therefore, significant research efforts have been made in recent years to understand distorted speech characteristics [4]. Acoustic features of distorted speech provide fundamental data required to develop speech reconstruction, speech recognition, and speech enhancement systems, which ultimately aim to improve the quality of living for these individuals [5, 6]. By analysing formant frequencies and voice onset time (VOT) of distorted speech (dysphonia) and comparing them to normal speech in New Zealand English, we aim to add to existing knowledge. Formants are very distinguishable frequency components of the acoustic signals produced by speech and are defined as resonant frequencies of the vocal tract. Temporal measures can also provide valuable information, particularly on pathologic voices. VOT is one of the temporal measurements which defines the length of time between the onset of the articulatory stop release burst (release of stop consonant) and the first glottal pulse of the following vowel [7, 8].

2. MATERIAL AND METHODS

All six subjects are native New Zealanders who have been born in NZ and speak English with characteristics of NZ English accent [9]. Three of them are healthy individuals (control group) and three with non-neurological dysphonia. In the dysphonic group, the clinical details are as follows: In Sub01, the source of the voice disorder was paralysed left larynx, Sub02 suffered from spasmodic dysphonia (the muscles in the larynx go into periods of contraction), and Sub03 underwent an organ-preserving operation to remove nodules on the vocal cords followed by radiation therapy which caused the formation of webs on his vocal cords. Therefore, apart from having some complications, the overall upper vocal tract in all three dysphonic participants has the same anatomy as a normal larynx. Audio recordings were made of subjects articulating /hVd/ words containing four vowels at extreme sides of quadrilateral vowel diagram (/i, æ, ɑ, u/). Praat was used to observe the formant frequencies from voice signal spectrograms and VOT calculation. The results were manually verified with MATLAB's power spectral density graph as described in [10]. The stop consonant (letter /d/ in "dark") to vowel transitional change (d- vowel) was chosen for the

purpose of this study. T-test has been performed at the p-value of 0.05 on the set of variables.

3. RESULTS AND DISCUSSION

Table 1 presents the average of formant frequencies from two recordings in four vowels (/i, æ, ɑ, u/) at extreme sides of the quadrilateral in the control group. The result of these measurements is consistent with the literature.

Notably, the formant frequencies in open-front vowels /æ/ in NZ English are shifted compared to standard Received Pronunciation (RP). Table 2 outlines the average of formant frequencies from two recordings of vowels (/i, æ, ɑ, u/) in dysphonic speech. Also, the formant frequencies are mainly in a close range for all three subjects.

Table 1: Average formant frequencies (from two recordings) in four vowels at extreme sides of quadrilateral vowel diagram in normal speech.

Sub01	/i/	/æ/	/ɑ/	/u/
F1	414	584	714	423
F2	1846	1772	1278	1360
Sub02				
F1	441	509	711	478
F2	1832	1951	1314	1772
Sub03				
F1	450	541	850	459
F2	1732	1996	1323	1469

Table 2: Average formant frequencies (from two recordings) in four vowels at extreme sides of quadrilateral vowel diagram in dysphonic speech.

Sub01	/i/	/æ/	/ɑ/	/u/
F1	496	612	732	478
F2	1723	1923	1405	1487
Sub02				
F1	450	550	741	405
F2	1714	1587	1323	1132
Sub03				
F1	455	586	718	396
F2	1655	1684	1296	1514

Table 3: Comparison of average voice onset time for the control and dysphonic groups with corresponding p-values.

VOT	Control	Dysphonia	P-value	Significant
/d/ in dark	27.3	23	0.9	No

Table 3 shows the average VOT of two takes for three control group subjects and dysphonic speech, respectively.

In Table 4, the p-values confirm that the differences between the first formants in all vowels are not significant. However, the results for the second formant in vowel /i/ and /æ/ are significantly different. We can see that in most vowels, the results of dysphonic speech are generally consistent with the control group (i.e. no significant differences). However, the voice signal has a slight upward shift in the first formant, and the hoarseness of the voice reduces the periodic form of the signal in the spectrogram.

Table 4: Comparison of average formant frequencies in four vowels at extreme sides of the quadrilateral vowel diagram for the control and dysphonic groups with corresponding p-values.

Vowel		Control	Dysphonic	P-value	Significant
/i/	F1	465	467	.45788	No
	F2	1803	1702	.00539	Yes
/æ/	F1	545	572	.12753	No
	F2	1906	1731	.02378	Yes
/ɑ/	F1	758	730	0.2152	No
	F2	1305	1341	0.3091	No
/u/	F1	391	405	0.1910	No
	F2	1533	1377	0.7444	No

4. CONCLUSION

We studied voice recordings of the healthy control group and dysphonic speech in adult New Zealanders. The first two formant frequencies of vowel articulation in four important vowels have been measured. In addition, an independent samples t-test was performed on the first and second formants of four main vowels of /i, æ, /ɑ/, u/ and for the VOT of the two groups. The results showed significant differences in some second formant frequencies but similar VOT and first formant frequencies between the dysphonic and the healthy group.

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Research on the application and implementation method of augmented reality Game-based learning with disabilities

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Abstract

The purpose of this systematic literature review is to explore the application of augmented reality-based gamified learning in the field of special education. The purpose is to explore and summarize the existing ARGBL game types and implementation methods, and to provide references for subsequent research in this field. In this study, the method of systematic literature review was used to retrieve the literature from the two databases of EIT library and Google scholar and conduct inductive analysis. The analysis results show that there are currently two types of games used in this field, which are augmented reality games that emphasize roles and augmented reality games that emphasize tasks. At the same time, there are two types of games in terms of gameplay. One is gameplay. Serious games, another teaching game that incorporates gamification elements. In terms of implementation technology, space equipment is the most widely used, while the identification and coverage of the physical world uses unmarked technology.

Methodology

This article will focus on the systematic literature review, studying the examples, implementation methods, strategies and problems encountered in ARGBL in education. The research object is the research papers on the application of ARGBL in special education. Therefore, the research questions of this study are:

RQ1: What are the AR Games used in leaning of people with disabilities?

RQ2: how are they implemented?

First of all, considering the quality of research, this article only selects documents that have been reviewed by peers. Literature data comes from two databases, EIT Library and Google Scholar.

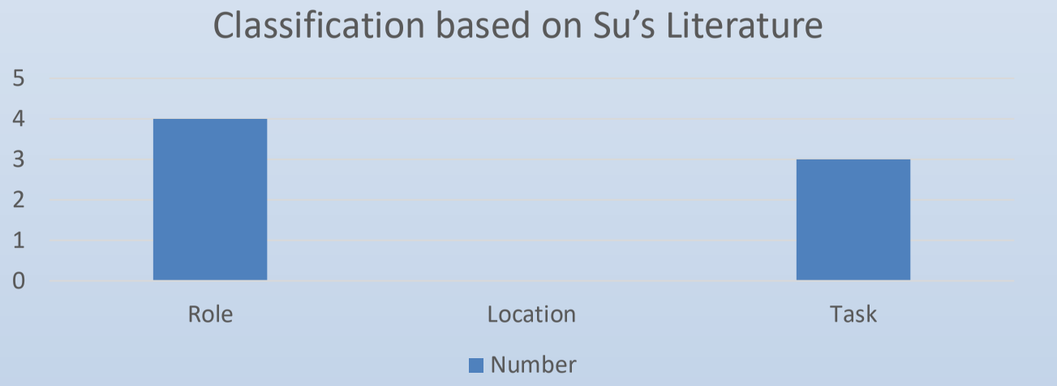
Secondly, for the preliminary collection of research materials, the search formula for this research is (educational games* or game-based learning* or computer games* or video games* or serious games* or digital games* or online games* or electronic games* or analogy Game*) and (learning* or education* or teaching*) and (augmented reality* or AR" or mixed reality).

Third, considering the evolution of technology and applications, the document time limit is 2016-2020

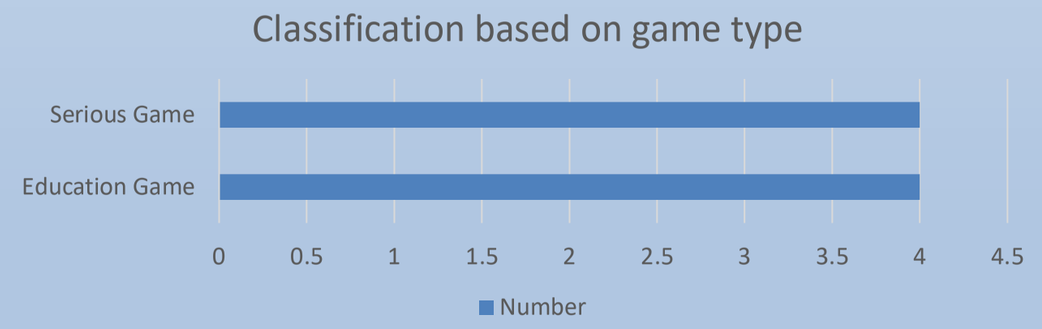
Fourth, the quality of the literature is evaluated according to the research theme. After preliminary screening, there are 15 ARGBL literature materials in the field of special education to be analysed. After further screening, 8 literature materials that do not contain the implementation process of augmented reality applications are eliminated. Finally, the remaining 7 articles describe the application and implementation of ARGBL.

Literature Review

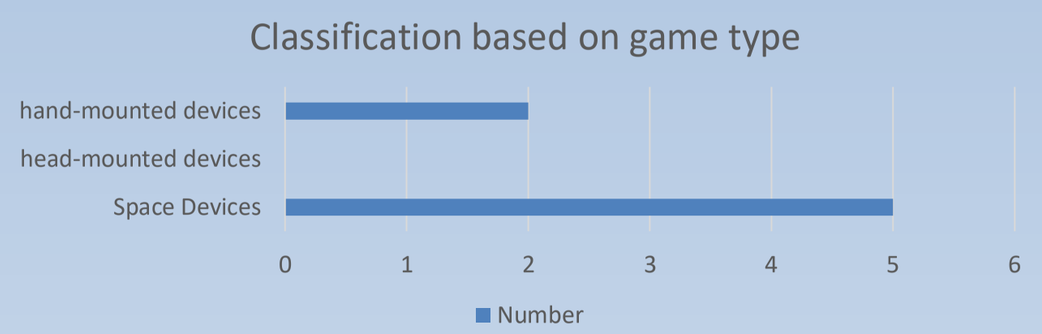
Educational games based on augmented reality can integrate the real world and virtual world into a fun and highly interactive ubiquitous learning environment (Kesim & Ozarslan, 2012). Su et al. (2016) divided augmented reality-based educational games into three types: augmented reality educational games that emphasize roles, augmented reality educational games that emphasize location, and augmented reality educational games that emphasize tasks.



For the classification of augmented reality educational games, the games are divided into educational games (EG) and serious games (SG). Educational games mainly emphasize the integration of gamification elements into augmented reality applications, while serious games emphasize students' use of augmented reality games.



for the classification of device categories, devices that exist in fixed locations in space and can track movable targets are called space devices, the second is head-mounted devices, and finally includes mobile phones and tablets. Mobile device classification. At the same time, Azuma (2001)



Discussion

RQ1: What are the AR Games used in leaning of people with disabilities?

According to the classification statistics in the literature review, the augmented reality games in the four public literature emphasize roles, and the augmented reality games in the remaining three literature emphasize tasks. According to Tobar-Muñoz et al. (2017) For the classification of augmented reality educational games, the games are divided into educational games (EG) and serious games (SG). Educational games mainly emphasize the integration of gamification elements into augmented reality applications, while serious games emphasize students' use of augmented reality games. To learn in. According to the above classification criteria, it can be concluded that the two serious games and iGYM games are all emphasizing the gaming experience. According to the above classification, it can be analysed that the main application games in the ARGBL field include serious games and educational games. Some games emphasize role participation, and the other emphasize tasks.

RQ2: how are they implemented?

In terms of implementation, the current learning based on augmented reality games mainly uses mobile and space devices to help build augmented reality situations, while all augmented reality games use unmarked scene recognition methods, and the game design context mainly emphasizes the integration with the real environment Interact with the emphasized body.

Conclusion

Through literature analysis, it is found that space devices and mobile devices are currently used in the field of ARGBL, and the gamification content is divided into augmented reality gamification applications that emphasize roles and augmented reality gamification applications that emphasize task resolution. In terms of game implementation, the main use of unmarked spatial recognition technology. At the same time, through the discussion of the two features in the augmented reality design, combined with the real environment or the interactive game that emphasizes the body, it is discovered. AR-based educational games can perform synchronous collaboration in indoor environments or asynchronous learning in outdoor environments. No matter which technology and method are used, attention must be paid to the integration of learning content and game elements. Through systematic teaching design, combined with learning theory, the learning content can be reasonably integrated into the tasks of educational games. Establish an immersive learning environment for students to help students carry out meaningful knowledge construction and inquiry learning.

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Factors affecting e-learning acceptance

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Abstract

The expansion of IT and the societal inclination to expand access to higher education have contributed to the exponential growth of e-learning adoption. The e-learning acceptance results revealed that the behavioural purpose was profoundly and favourably influenced by the facilitating conditions, efforts expectancy, performance expectancy and social influence. The acceptance of e-learning has a significant and positive influence on facilitating conditions and behavioural intention. In the meantime, the behavioral intention has been profoundly shaped by confidence and passion for e-learning in the future of the students.

Literature Review

The Unified Theory of Acceptance and Use of Technology (UTAUT) Model

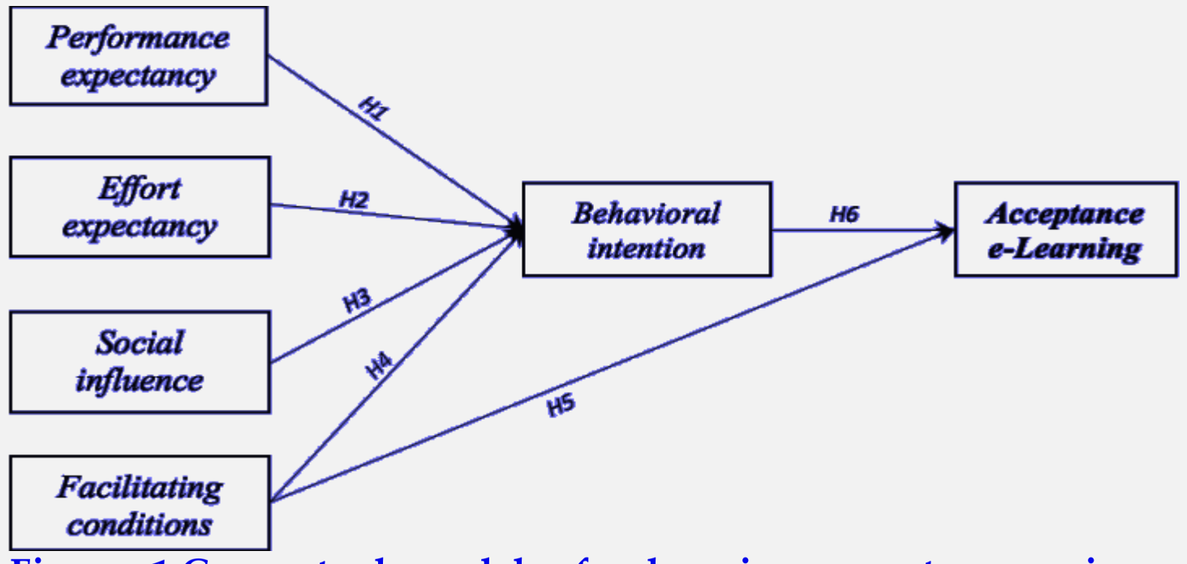


Figure 1.Conceptual model of e-learning acceptance using UTAUT (from Mahande & Malago, 2019)

Performance Expectancy (PE) is how high a person expects him/her to gain from the method in each position or service.

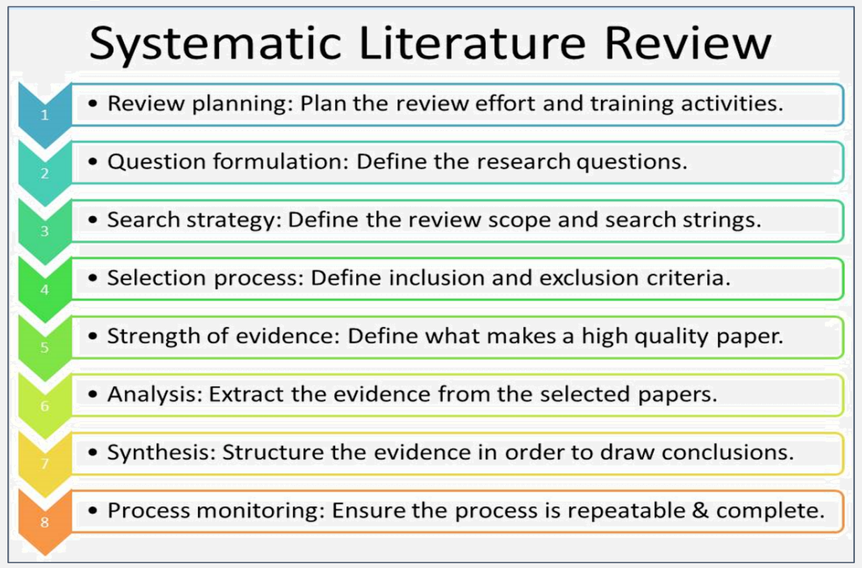
Effort Expectancy (EE) is the level of ease of access of the user to the system or technology.

Social Influence (SI) is the extent to which an individual perceives that other parties find system/technology to be best used.

Facilitating Factors (FC) is the degree that a person feels technological and organizational infrastructure to enable the use of a system and technology is available.

Methodology

Research Question: What are the factors affecting e-learning acceptance?



29 Peer reviewed articles in English during 2015-2020 selected for the study

Findings

Performance Expectancy (PE) positively affects behavioral intention (Bellaaj et al., 2015; Mahande & Malago, 2019). Higher the performance expectancy of the user, the higher the desire to use the system (Ibrahim et al., 2017).

Effort Expectancy (EE) positively impact the intention of using e-learning technology (Decman, 2015; Doleck et al., 2017; Kocaleva et al., 2015). The users' interface for e-learning apps should be simple and include main features that minimize user learning effort (Ngo Nhu Tran, 2016). Nurkhin (2020) only mentioned that effort expectancy may not have a major impact on behavioral intention.

Social Influence (SI) on behavioral intention was strongly favorable (Hrtoňová et al., 2015; Mahande & Malago, 2019; Tarhini et al., 2016). Other students' engagement and motivation to pursue the e- learning method became aspects of social influence that required further focus (Mahande & Malago, 2019). The social impact often involves programs where the purpose or behavioral usage of people can be affected by attitudes of others about the need to use technology and their interest in e-learning (Bellaaj et al., 2015; Vululleh, 2018).

Facilitating Factors (FC) promoting e-learning adoption, such as Internet speed, student's skills, infrastructure were strongly influenced. This means that extra care should be given to the facilities. The e-learning adoption was profoundly and positively influenced by facilitating conditions and behavioral intentions (Ali et al., 2018; Doleck et al., 2017; Tarhini et al., 2016).

Discussion

Decman (2015) identified that three latent standard variables of the UTAUT model affect the behavioral intention (BI): Performance Expectancy (PE), Effort Expectancy (EE), and social influence (SI). The facilitating condition directly affects the e-learning acceptance.

Behavioral intention is the key to the intention of a person to accept e-learning.

Conclusion

To conclude, it was observed that there was a significant link between the behavior of e-learners and behavioral intention and effort expectancy influenced user behavior, although a lower role in the social influence was observed as applied to other factors, which affected the variable behavioral intention and encouraged user behavior. Facilitating condition and behavioral intentions were factors that proved to have the greatest influence on e-learning acceptance. The students understand exactly, and assistance obtained from lecturers and colleagues were greatly influenced by the terms of facilitation when difficulties occurred. In the meanwhile, behavioral intentions were highly informed by the students' confidence in the future of e-learning and their dedication to ensuring e-learning can be incorporated in all subjects sustainably.

Key References

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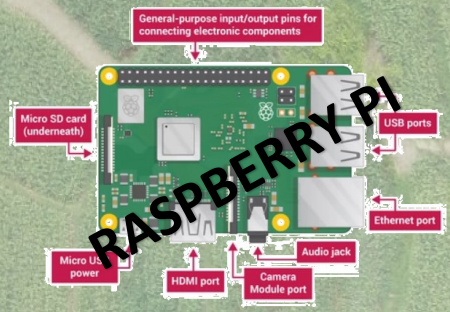
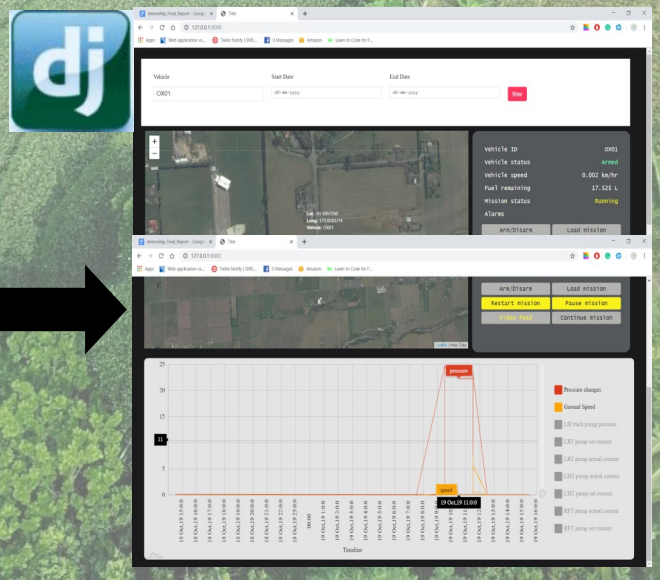


PROJECT

These tasks are the major part of the project dealing with connections, protocols, database and dash-board. Here you can see that first, the connection is being made using MQTT transferring the data from the vehicle to the AWS account. After that connec-tion is being made with the AWS cloud and data flows into the database. This will allow the user to view the dashboard consisting of vehicles details such as Vehicle Id, location, graphs and so on.

VEHICLE

DATA



THE SMART MACHINE

The organization where I did my internship is named as THE SMART MACHINES COMPANY. It was established in year 2017 and is based at three locations i.e. Napier, Blenheim, and Auckland.

Company's main goal was to concentrate on finding an effective and practical solution for the issues in the vineyards.

At that point, he thought of this plan to build up an independent viticulture tractor or some other similar creation which can spare the trouble of looking for drivers, labourers and their expense for work.

TOOLS & TECHNOLOGIES USED

This project uses AWS technologies such as IoT core, AWS cloud database, SNS notification etc. I used Django framework, HTML, CSS, JavaScript, and more of python as a programming language.

EIT

Dr. Emre Erturk (EIT Intern Supervisor)

Binny Tandon (Project Intern)