LOW CARBON LIVING CRC

RP: 3015 Learning for Low Carbon Living

The Building Quality Passport - Mobile Learning for Australian built environment trades and professionals

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- Swinburne University of Technology
- University of Melbourne
- Master Builders Association (Victoria)
- BuildingSMART Australasia
- Victorian Building Authority
- Sydney Costal Councils Group

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The author(s) confirm(s) that this document has been reviewed and approved by the project's steering committee and by its program leader. These reviewers evaluated its:

- originality
- methodology
- rigour
- compliance with ethical guidelines
- conclusions against results
- conformity with the principles of the Australian Code for the Responsible Conduct of Research (NHMRC 2007),

and provided constructive feedback which was considered and addressed by the author(s).

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Executive Summary

This final report supports the completion of the Cooperative Research Centre for Low Carbon Living (CRC LCL) Research Project (RP) 3015: *Increasing knowledge and motivating collaborative action on Low Carbon Living through team-based and game-based mobile learning* (2014-2018). The project aims to address a challenge which is central to the CRC LCL's stated purpose, of overcoming barriers to the adoption of low-carbon construction processes, products and services. Regardless of technological advances or policy changes toward energy efficient and low carbon building design, the quality of construction practices needs to improve to harness the significant opportunities available in the market. The central question for this project was: How might we facilitate a sense of responsibility toward embedding sustainable practice into the culture of the tradespeople and builders?

Input from project industry partners, as well as semi-structured interviews and surveys with trades instructors, builders and students supported the contention that leveraging situated peer to peer and authentic learning on the building site (contextualising rather than abstract instruction), combined with social learning strategies might be well suited to addressing these issues during teaching of trades apprentices, builders and design professionals.

This project therefore focussed on how this could be facilitated by mobile learning (M-Learning) using smart-phone technology to align the learning needs of apprentices, the instructional needs of trainers, and builders needs for work-site efficiency, business benefits through continuous improvement, compliance, quality assurance tracking, and documentation. It recognises that "…learning and acting are interestingly indistinct, learning being a continuous, life-long process resulting from acting in situations" (Brown, Collins and Duguid 1989).

The technical questions that drove this research were how M-learning could:

- Capture 'actions' being taken on building sites in a way that integrates with the learning that is taking place in that moment;
- Capture evidence of code compliance actions that could provide a commercial benefit to builders, and
- Support course trades instructors and courses to achieve better learning outcomes.

In 2015, the National Energy Efficient Building Project (NEEBP) Phase II found that the building regulatory system, which supports building compliance and energy efficiency verification of buildings, is not taking advantage of technological affordances (NEEBP P11, 2015). In addition, the NEEBP Phase 1 report found, particularly in the housing sector, that there is a widespread lack of physical inspections resulted in low quality and low compliance linked to energy efficiency measures (NEEBP P1, 2014). The Phase II project looked to take advantage of the high use of mobile devices, tablets and other technology to document regulatory requirements. The study recommended the development of a mobile application for capturing a date stamped photograph of completed work with the job site address and builders' details as a form of electronic documentation called an electronic building passport (NEEBP PII, 2015, p. 40).

Considering these findings, and the need to address barriers to low-carbon and sustainable building, RP3015 further focussed on how to capture works that are complaint with energy efficiency provisions of the National Construction Code (NCC), and more specifically improve engagement among building trades apprentices in learning about low-carbon construction. This was done in order to raise the profile of the environmental importance of achieving the NCC energy performance provisions, and to provide a record of code compliant work that could be accessed by builders for reporting and marketing purposes.

The outcome of the project is a design for an M-Learning interface application for smart-phones that facilitates documentation of code compliant construction works by trades apprentices, that is automatically assigned to a project so a builder can compile an electronic "building-quality passport".

The captured evidence (as photos or videos) is also automatically assigned to the apprentice's student I.D. or course code and can be compiled and uploaded as assignment or reference material through a training provider's learning management system. This enables credit to be attained for skills acquired outside of formal course schedules, and helps instructors better track student progress and provide more relevant and timely feedback.

The design of the M-learning interface and user 'journeys' was informed by research into the emotional needs of technology users. It was further refined by a professional design firm and presented to the project as 'in-vision' wire-frames. These designs can be accessed via the following links:

- Student
- Builder
- Surveyor
- Facilitator

These wireframe designs can now be further developed into a working application that can be field tested with industry partners. The project team is now exploring the feasibility of an ARC Linkage proposal to take this next step.

Project Overview

The scope and objectives of this project changed during its course to adapt to new research findings and in response to the outcomes of other CRC projects.

Original Project Objectives

The project objective was to investigate the use of mobile learning (m-learning) to equip and motivate professionals, tradespeople and consumers to embrace Low Carbon Living (LCL) and work collaboratively to achieve change. The project mapped the drivers and motivations of professionals and tradespeople to deploy LCL solutions as well as the emotional and knowledge goals of consumers undertaking LCL projects. These research findings were to inform the design of m-learning modules, which aimed to:

- Increase knowledge of LCL-alternatives to existing practices, products and services;
- Enable and motivate consumers, professionals and tradespeople to work collaboratively towards LCL-outcomes; and
- Produce 'expert' consumers who drive demand for LCL-solutions.

Originally, the project aimed to advance the CRC's education and capacity-building goals through:

1. *Three PhD completions with these proposed topics:*

- Team-based m-learning to motivate and enable an integrated approach to LCL projects by professionals and tradespeople;
- Modelling motivations, values and emotions of learners in order to improve m-learning on LCL;
- Creating the expert consumer: Team-based and game-based m-learning as an enabler of social innovation on LCL.

2. *The design, development and delivery of team-based m-learning modules on LCL, which:*

- Raise the knowledge and motivation of professionals and tradespeople in relation to implementing low carbon alternatives to existing practices;
- Facilitate a team-based approach to design and decision-making on built environment projects, which centres on increasing awareness of the interrelationships between the trades and professions and the impact of their practices and decisions on LCL outcomes.
- Raise the knowledge, confidence and motivation of consumers to pursue LCL outcomes;
- Increase the capability of consumers to work collaboratively with professionals and tradespeople as 'expert-consumers' in pursuit of low carbon outcomes.

3. *A summary project report and presentations for the CRC Board and CRC partners.*

The project is central to the objectives of the CRC's Program 3: *Engaged Communities* and delivers on the CRC's stated outputs of *Education and Capacity Building*. The content of the M-learning modules were informed by the findings of the Education and Training Scoping Study with ongoing and active consultation with the CRC's research and industry partners to identify, agree and prioritise topics to be included in modules, and ensure existing knowledge as well as the new knowledge and insights developed in the CRC are incorporated. CRC partner organizations were used as research sites and as pathways to recruit learners into the m-learning modules including Swinburne TAFE and Sydney Institute. The modules looked to encompass the CRC's areas of expertise, with the option of adding or updating modules as research results become available or as new priorities are identified.

CRC_LCL Outcomes

- R3.4.3 Initial design of educational, training and monitoring programs for the specific communities across the CRC completed.
- R3.4.6 Pilot educational, training and targeted professional development program for the built environment industry established.

The mobile program under development is for trade apprentices, building professionals.

- R3.4.10 Provision of enhanced education and training strategies via feedback from CRC research outcomes completed.

Revised Project Objectives

When the project had a change of leadership, the CRC LCL Board advised the new Project Leaders of the recommended target audiences based on other projects in progress. The new target group included builders and trades people. Therefore, the project team aimed to develop a functioning prototype of a mobile learning application with 2 'streams or modules':

- 1 module for building students (Cert IV level and above)
- 1 module for trade apprentices (Cert III level)

The key target area of the building sector was residential (single residence, multi-residence up to 3 stories) building compliance during onsite construction. The research team looked to develop a pedagogically appropriate learning and assessment app, facilitating peer and situated learning; incorporating game-based elements, designed to actively engage and motivate trade students with sustainability compliance in their workplace. The opportunity may also offer an advantage to local councils, private building surveyors and building authorities to facilitate the tracking and recording of compliance documentation as submitted by builders and trades (electrical/plumbing). Further, the compilation of documented code compliant works could be of value to builders and trades seeking to demonstrate to potential clients their quality of construction compiled into an electronic 'building quality passport' (BQP).

Project Team

The multidisciplinary project team included researchers from Swinburne University of Technology and Melbourne University who contributed to the project by guiding the three PhD candidates and supporting the application development.

Three PhD students were recruited to support these research topics:

- Modelling motivations, values and emotions of learners in order to improve m-learning on LCL (Uni. Melbourne)
- How to improve collaboration and motivation of built environment professionals toward high performance building design (Swinburne Uni.)
- Team-based and game-based m-learning as an enabler of social innovation on LCL (Swinburne Uni.)

The students engaged in the project were not software developers, but researchers focused on identifying:

- Existing engagement (provision and demand) in education for sustainability (energy efficacy and carbon reduction strategies and practices);
- Technology use and learning needs specific to each group within the context of the work practices;
- Emotional goal models of each learning group;
- Identifying the potential interventions to inform the planning and design of the mobile learning program;
- Collaborative design methods and technology;
- The learning motivators and gamification opportunities to integrate into the learning process.

The outcomes of the research were used to inform the development of the prototype mobile learning application. Field research and empirical analysis are critical next steps required to develop an effective mobile learning pilot program for the target groups.

Advisory Committee

The Advisory Board for this project included the following organisations:

- Swinburne University of Technology
- University of Melbourne
- Master Builders Association (MBA) (Victoria)
- BuildSMART Australasia
- Victorian Building Authority
- Sydney Costal Councils Group

As part of this project, the mobile learning application was prototyped in 2017 with a future plan to develop the modules thereafter contingent on government, and industry support in 2018. Project report completed and presented to the Board, including recommendations and proposal for the ongoing offering of the modules. Based on the project outcomes, the industry partners the MBA are interested in the opportunities for their education cohort of trades, builders and designers.

However, after consultation with the Project Advisory group and TAFE and VET stakeholders, it was determined that the app should augment existing learning platforms and models, rather than developing new curriculum modules or simply offering access to those modules on a smart-phone. The key need was identified as being improving opportunities for learning on the job and capturing evidence of skills and competencies that are developed on-site, often out of sequence with course schedules. Tomi Winfree presented the prototype to the Master Builders Association (Victoria) and received overwhelming supporting and interest in the mobile application. The group indicated that the only competitors could be one safety learning platform and a project management application widely used in the industry. However, the safety training platform doesn't deliver training but rather hosts training content allowing access for others to deliver training.

Outcomes could also inform the training of local government councillors, technical staff and contractors who engage on building projects. RP3015 outputs were therefore designed to complement, not compete with existing project management, learning management and training apps.

Publications

The project research generated 8 refereed conference papers and journal articles

Journal articles:

1. Winfree, Tomi, et al. (2017). “Learning for Low Carbon Living: The potential of mobile learning applications for built environment trades and professionals in Australia.” Procedia Engineering.
2. Melles, G., Winfree, T., Graham, P. (2019). Collaborative Design of Mobile Interfaces for Building and Construction Education. In: ICoRD’19 – *Enabling Technologies & Tools*, Springer.

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Peer-reviewed conference articles:

1. Sherkat, Mohammad, et al. (2016). “Does It Fit Me Better? User Segmentation in Requirements Engineering.” *Proceedings of the 23rd Asia-Pacific Software Engineering Conference (APSEC)*, 2016.

Journal articles under review:

2. Sherkat, Mohammad, Tim Miller, Antonette Mendoza, and Rachel Burrows. "Emotionalism within People-Oriented Software Design." ACM TOSEM (2018).
3. Sherkata, Mohammad, Antonette Mendozaa, Tim Millera, and Rachel Burrows. "Emotional Attachment Framework for People-Oriented Software." Software: Practice and Experience (2018).

Conference presentations:

1. Sherkat, Mohammad, et al. (2016). “Does It Fit Me Better? User Segmentation in Requirements Engineering” Oral presentation at the 23rd Asia-Pacific Software Engineering Conference (APSEC), 6-9 December 2016 in Hamilton, New Zealand.
2. Winfree, Tomi, et al. (2017). “Learning for Low Carbon Living: The potential of mobile learning applications for built environment trades and professionals in Australia.” Oral presentation, SBE16 International High-Performance Built Environment Conference, hosted by UNSW, Australian Maritime Museum, Sydney, New South Wales, Australia, 17-18 November 2016.
3. Winfree, Tomi (2016) “Mediating digital technologies in the Australian built environment.” Oral presentation, Seventh Nordic International Society of Cultural-historical Activity Research Conference, University of Copenhagen, 16-18 June 2016.

Learning Challenges for Low-Carbon Construction Practices

Professionals and tradespeople cannot promote low carbon building options unless they know of proven solutions and have confidence to implement them. Consequently, without effective education and training they continue to 'lock in' high carbon options. Studies of education and training in sustainable and low-carbon building practices indicate that collaborative learning approaches are the most effective to address this issue. The research challenge addressed by this project is how to equip and motivate professionals, tradespeople and consumers to embrace opportunities by learning collaboratively to adopt low carbon products and services.

The Need to Re-Engage Trades Apprentices & Building Practitioners

The building sector is the third-largest economic sector in Australia with total construction activity valued at $4.45 billion in 2015, producing eight percent of the gross domestic product and directly employing over one million people or nine percent of the workforce while indirectly supporting a large upstream and downstream supply chain [4]. The sector is grappling with a cultural shift impacting on the planning, design, building construction and operational stages, and work practices due to the increasing complexity of buildings and specialised roles based on [5,6,7]:

1. Increasing demand for higher performing building linked to urbanisation, sustainable built environments and reducing greenhouse gas emissions
2. Increasing use of digital technology, in particular building information modelling technology and management;
3. Increasing demand for collective design and collaborative construction or co-configuration demands.

Despite this increasing demand, highly experienced and skilled professionals and tradespeople are unlikely to promote low carbon or sustainable building options to clients unless they have knowledge of proven solutions and the confidence to implement them. Consequently, without effective education and training they can continue to 'lock in' high carbon options, while locking out or limiting the implementation of available low carbon opportunities. Studies of education and training in sustainable and low-carbon building practices indicate that collaborative learning approaches (and indeed, learning to collaborate) are necessary in order to develop the skills and working relationships necessary to optimise sustainability and carbon reduction opportunities during design, engineering, construction and operational phases of a building project.

However, recent Australian studies[1] focusing on knowledge management and engagement of building trades have found that practitioners have little or no engagement in training programs on sustainability, energy efficiency and low carbon strategies because:

1. Environmental Performance requirements in buildings are not taken seriously: Lack of effective environmental performance policy policing reinforces a sign-off culture where there is little incentive to learn how to implement sustainability strategies because there is little risk of being caught for non-compliance.
2. Sustainability, energy efficiency and carbon reduction are not viewed as common practice, but rather seen as a specialization
3. Mainstream audiences must also engage with these key topics to move beyond narrow specialisations like Green Star and bespoke housing [9] as part of compliance with the NCC.
4. The language used in training materials is too abstract and the information provided is overly complex and difficult to understand for many skilled trades and professionals.
5. There are currently no mandatory industry based CPD requirements that are specifically linked to energy efficiency, carbon reduction strategies or sustainability.

Overall these studies found that "a major structural flaw undermining the goal of optimal energy efficiency was … a generally poor attitude across significant parts of the construction industry to both (i) quality workmanship, and (ii) energy efficiency [9]." Furthermore, the findings concluded that the problems were systemic and not isolated to individuals, but rather a combination of flaws in the regulatory environment, extreme cost pressures and an attitude and "culture that accepts 'shortcuts' or 'near enough is good enough' [9]" that highlight the need to address the "failings of the pre-vocational system and the narrowness of the form of competency-based training upon [which] the system is founded [9]."

[1] Phase I of the National Energy Efficiency Building Project1 [9]]& (RP3022 CPD Policy study, 2016).

The knowledge review of the NEEBP [9] concluded "the key problem is not the lack of availability of quality information or training but that what is available does not offer practical application to implementation - the 'how to' information, education and training – that can readily be integrated into daily work tasks." The portion of the NEEBP study related to knowledge management and engagement concluded that: "although a diverse range of issues related to the NCC, rating tools, inspections, etc. were expressed, comments on knowledge management and engagement were quite consistent across the nation. The general message is that there is a significant need to review and support information and training related to:

1. Energy conservation measures, energy efficiency, carbon abatement and sustainable building methods;
2. Compliance with the NCC and assessment;
3. Responsibility sharing and accountability of various industry roles to ensure each role has the correct information and skills for compliance;
4. Continuing professional development and regulatory license requirements [9]."

In summary key findings indicate that, "the attitudinal and knowledge base of competencies were seen as being diluted through the lack of emphasis on basic sustainability thinking, foundational understanding of energy efficiency concepts, and critical thinking. This often resulted in simplistic teaching towards, and assessment of, minimum standards of skill performance [9]" with new approaches to pre-vocational education and training being vital as well as readily availability and contextualised information specifically relative to the job at hand, and contextualised engagement with those in the existing workforce to enable integration into practice [9]. A lack of competency and willingness to learn skills necessary also contributes to a lack of compliance with energy performance requirements of the National Construction Code.

Lack of Compliance with the National Construction Code addressed through Learning

In 2015, the National Energy Efficient Building Project (NEEBP) Phase II found that the building regulatory system, which supports building compliance and energy efficiency verification of buildings, is not taking advantage of technological affordances (NEEBP P11, 2015). In addition, the NEEBP Phase 1 report found, particularly in the housing sector, that there is a widespread lack of physical inspections resulted in low quality and low compliance linked to energy efficiency measures (NEEBP P1, 2014). The Phase II project looked to take advantage of the high use of mobile devices, tablets and other technology to document regulatory requirements. The study recommended the development of a mobile application for capturing a date stamped photograph of completed work with the job site address and builders' details as a form of electronic documentation called an electronic building passport (NEEBP PII, 2015, p. 40).

Considering these findings, and the need to address barriers to low-carbon and sustainable building, RP3015 focussed on how to capture works that are complaint with energy efficiency provisions of the National Construction Code (NCC), and more specifically improve engagement among building trades apprentices in learning about low-carbon construction. We also wanted to investigate whether mobile learning technologies could raise the profile of the environmental importance of achieving the NCC energy performance provisions, and to provide a record of code compliant work that could be accessed by builders for reporting and marketing purposes.

To engage practitioners in a dialogue to shape the next stages of development of the mobile learning program the team held an industry-based focus group [19]. The focus group [19] was conducted over three hours with representatives from commercial and residential design and construction companies, a building product manufacturer, the building regulatory authority, academic research institutions, national vocational education, and a key industry association.

The discussions were used to elicit information about the use of mobile devices in the industry sectors, identify the key target audiences requiring knowledge and skills development to motivation action and break the cycle of 'locking in' high carbon options, while locking out or limiting the implementation of the available low carbon opportunities (Table 2). The preliminary data collection from the focus group was completed using qualitative methods and a series of one-on-one interviews with lead trade teachers and a real estate representative. The building trades include the fields of plumbing, carpentry, building, electrical and landscaping.

Table 1: M-Learning App Intended Users

Primary Learning Users	Secondary Business Users for Compliance Evidence
Students - Trade apprentices	Trades (electricians, plumbers, carpenters, etc.)
Students - Training to become builders	Builders
Facilitators / Trainers: • Swin TAFE • Syd Institute (NSW TAFE) • HIA • MBA • MPMSAA	Companies (e.g. HVAC, installers)
Employers (building industry mentors being sole traders / trades and builders)	Certifiers - Building Surveyor / Inspector (private) - could also potentially mentor learners particularly those studying to become builders who don't have access to building sites
	Local Councils or Local Government Authority (Building Surveyors)

These participants helped identify key aspects related to the benefits or advantages of using mobile devices and the need to for continuous engagement in professional development to contribute to high performance buildings. The focus group indicated that there is a continuous demand to up skill, network and engage in formal CPD, but also highlighted some the potential alternatives to formal engagement. However, there were also a number of challenges associated with using mobile devices and engaging with clients and customers about sustainability, energy efficiency and carbon reduction strategies. The participants identified the benefits and requirements of engaging in high performance buildings, being:

- Social conscience
- Peer group interests, activities and attitudes
- Industry awards (competition)
- Tender requirements
- Regulations or industry standards
- Energy prices
- Market demand (clients and customers)
- Company leadership from the top down in both commercial and residential markets
- Higher staff retention rates in commercial office spaces due to the high replacement costs associated with staff turnover.
- It's not about being a leader necessarily, but avoiding being the 'others' who are not engaged in practice and are eventually unable to compete in the market
- The need for an energy performance label for residential buildings to help drive the market for energy efficient houses.

To keep up to date with regulations, standards, materials and methods, continuous upskilling, networking and formal CPD is considered essential. Green Star accredited professionals for example, with the Green Building Council of Australia are required to collect fifteen continuing professional development (CPD) points per annum to stay certified. This enables them to compete in the commercial market and bid for jobs and to network at industry events.

Practitioners also mentioned alternatives to formal engagement such as simply talking to mates on the jobsite or in the office. Some try to learn by using online resources. However, there are often limiting factors reducing engagement, particularly the time commitment and the cost of training. Tradespeople and apprentices expressed a preference to learn on the job, not in a classroom.

Informing the Concept Design for an M-Learning Platform

Our first activity was to develop a concept design for the M-Learning App, drawing on the existing literature on M-Learning best-practices. Recent studies show that M-Learning is enhanced by a mix of on-line and face to face learning experiences, while

motivation for learning can be enhanced by 'gamification', 'team based' learning and open learning approaches. To inform the concept design the project team considered four issues:

1. The approach in which the learning is delivered (mobile learning)
2. The pedagogy used to deliver the learning, (discovered through understanding the needs of trade apprentices)
3. The modes we use to engage the learning (intrinsic/extrinsic motivation such as game-based learning or gamification)
4. The knowledge and understanding (sustainability compliance).

The Approach: Online learning and M- Learning

A report from the Foundation of Young Australians found the growing use of automation and digital learning tools will change how teachers do their jobs. The report predicts by 2030, teachers will routinely use digital technology to make education a more interactive, student-centred experience. This means they will likely spend less time lecturing and more time facilitating self-directed learning (FYA, 2017).

Online learning is learning that takes place on the internet. M-learning', is a variant of online learning that has been configured to take place on mobile devices, including smart phones and tablet devices e.g. iPad. The widespread availability of mobile devices has meant that learning may occur wherever internet access is available. There is significant literature on online learning, including summaries of national and international experience (Allen & Seaman, 2013; U.S. Dept. of Education, 2010) and analyses of different educational delivery models (Hill, 2012). An authoritative and comprehensive meta-analysis of research on the effectiveness of online learning undertaken by the U.S. Department of Education, concluded that students in online conditions performed modestly better, on average, than those learning the same material through traditional face-to-face instruction. (U.S. Dept. of Education. 2010, p. xiv). The meta-analysis also found that instruction combining online and face-to-face elements had a larger advantage relative to purely face-to-face instruction than did purely online instruction. (U.S. Dept. of Education. 2010, p. xv)

Thus, contrary to the expectations of many, face-to-face instruction was found to be the least effective mode of learning, online learning was more effective, and a blended approach combining some elements of both was most effective. This meta-analysis lends support for the blended approach taken in this project, which uses m-learning to support either project-based or institutional learning environments.

There is a growing body of evidence supporting the effectiveness of m-learning as a mode of learning. Studies show that learners value the 'anytime, anywhere' characteristics of m-learning (Brown, 2010; Paine Schofield et al., 2011) or, as one respondent to a recent Australian study put it 'The ability to have the world's information at my fingertips' (Martin et al., 2013, p. 58). Martin et al. (2013, p. 59) found that motivation to engage with m-learning increases when students are given 'meaningful and authentic learning tasks that are practical, relevant and relate to the real world'. Students value 'fun' elements within m-learning lessons as well as the ability to communicate easily with others. De Waard (2013) found that opening up mobile access to a course led to an immediate, ongoing increase in learner interactions. The study suggests that m-learning may be a particularly effective means of raising levels of engagement between learners as well as engagement with course materials.

Pedagogy for Trades and Building Certificate Students

Due to the lack of compliance with the National Construction Code (NCC) as reported in the National Energy Efficient Buildings Project Phase I (NEEBP, 2014) the learning outcomes aimed to focus on the required sustainability competencies in the national trade education curriculum aligned to the NCC. The focus for specification of the m-learning app therefore became oriented around enabling, and encouraging the capturing of skills required to demonstrate code compliant construction. This was done by identifying 6-10 learning outcomes from the National Curriculum (Table 1) which could be reimagined within a mobile learning environment.

Table 2: Summary of National Construction Code Energy Efficiency Requirements selected (Modified from NEEBP PII, 2015, p.22).

Energy Efficiency Requirements (NCC)	Explanation
Building Envelope Thermal Performance: calculation of space heating and cooling loads	Heating & Cooling Loads and related star rating
Building fabric: elements that impact on thermal performance	Envelop – roofs, floors, external walls, windows, doors Windows/doors Glazing (physical properties) Glazing (amount of glazing) Glazing (shading / sun control) Insulation Roof lights
Building Sealing: elements that impact on air infiltration rates and hence heating and cooling loads	Chimneys and Flues Construction of roofs, walls, floors Doors Windows Evaporative coolers Plumbing pipes
Air movement: elements that impact on the need for mechanical heating and cooling	Air movement Ventilation openings (walls, roof, floor, windows and doors Ceiling fans Halogen down lighting Evaporative coolers
Services: the energy efficiency of main building services	Insulation of services (e.g. heating and cooling duct work; hot water pipes) Lighting (energy efficient) Water heating (low greenhouse gas emissions) Swimming pools and spas (energy efficiency of heating, pumping and cleaning systems)

After discussions with project stakeholders it was decided to enable learning milestones relevant to each of the above energy efficiency requirements to be captured by the M-Learning platform. However, due to time and budget limitations of the project the learner cohorts selected for interview were restricted to plumbing, electrical and building certificate students.

Trade apprentice teacher interviews were completed in 2015 to support the initial understanding of the cohort and learning methods with a second round of interviews conducted in 2017 with key industry stakeholder groups. A hybrid process was then completed to support the module design to develop the prototypes of smart phone applications, including games with a UX designer. We engaged with a UX designer to workshop, plan and develop the mobile learning application prototype to complete the project, being the same designer who has designed the renovation prototype (RP3021) to support continuity. The following challenges and needs were distilled from the interviews:

Challenges

- Employers prefer learners to be on site and not at TAFE
- Phone usage onsite is seen as wasting time
- Tablet and phone devices not currently used by facilitators or learners for VET learning
- Course / assessment information and industry standards documentation is text heavy and difficult to navigate
- Limited connection to real world and sites
- Limited social connections
- TAFE facilitators and employers have limited communication
- Limited communication between fellow learners and facilitator
- Underdeveloped higher-level skills, e.g. evaluation and reflection
- Low number of students (cert IV level) working for builders while doing TAFE

Opportunities

- Learners can spend more time on site and complete assessment material contextually
- Improved communication between TAFE facilitators and employers
- Streamline facilitators and learners workflow
- Streamline boss and employee or sole trader workflow
- Assessments, quizzes and some course information easily accessible
- Enable group communication and support from peers, employer and facilitators
- Provide trackable evidence of work and documented building evidence.

Overall it became clear that the key to re-engaging trades learners in education more broadly, and about energy efficient buildings and low-carbon construction in particular, was to enable situated learning (learning 'on-the-job'), provide peer-peer learning opportunities, re-engage mentors and employers as stakeholders in, and beneficiaries of the learning process, make it easier for teachers and students to track progress in attaining the key competencies of the National Curriculum, and being provided with real-time feedback. The performance brief for the platform was then defined as a pedagogically apposite learning and assessment app, facilitating peer and situated learning; incorporating game based elements, designed to actively engage and motivate trade students with sustainability compliance in their workplace. These findings were re-drafted into the following set of guiding functional and design objectives:

Functional Objectives

- Improve the learning experience of the trade apprentice/student
- Bridge formal and informal learning environments
- Motivate students with unpopular and unpalatable topics.
- Facilitate student developed content
- Encourage peer to peer engagement
- Encourage the 'mentor' role within the educational framework
- Facilitate situated learning

Design Objectives

- Develop and prototype learning pedagogies using familiar informal learning methods trade students are comfortable with, on a mobile platform.
- Identified pedagogies will inform the design process utilising ubiquitous technology found inside the everyday mobile device.
- Develop specific learning tasks which can be executed on the job through an app which can facilitate the curation of a digital portfolio.
- Leverage intrinsic motivators through peer-based learning.
- Leveraging extrinsic motivators with credentialing.

Key stakeholders were then presented with these objectives in a series of workshops to develop the design concept for the mobile platform prototype. The first workshop was held on the 3rd August 2017 in Melbourne with representatives from:

- NSW TAFE
- Swinburne PAVE (TAFE)
- Master Builders Association (Victorian Branch)
- Building Leadership Simulation Centre (Master Builders Association)
- Housing Industry Association
- Sustainability Victoria
- CodeSafe
- SA Department of the Premier and Cabinet (NEEBP - Energy Efficient Buildings, Energy and Technical Regulation)
- Mechanical Association of Australia (MPMAA)

Prototype modules were then developed, tested and redesigned as a mobile learning application for the confirmed cohorts of builders and trades engaging in onsite construction in close collaboration with the potential end users through a series of ongoing workshops:

- Industry meeting held on first iteration – 22 September 2017
- Team meeting held to review feedback and inform the second iteration – 28 September 2017
- Modules launched for testing with the Advisory Board and key stakeholders October – December 2017

Modes for Engaging Learners

The learning design is based on several ways of learning which are natural to the apprentice, authentic, situated learning and peer-based learning. A mind map of the many elements that influence trades apprentice learning was then created to communicate the brief. The use of situated learning as an approach to the design of mobile learning environments is relatively recent to the advent of mobile and ubiquitous technology such as GPS, accelerometer, gyroscope and the camera provide the tools to augment and situate the learner in ways that have only been possible previously with expensive and complex systems. Herrington and Oliver (cf. Herrington, Reeves, & Oliver, 2010) propose a list of nine key elements that characterise an optimal authentic learning experience.

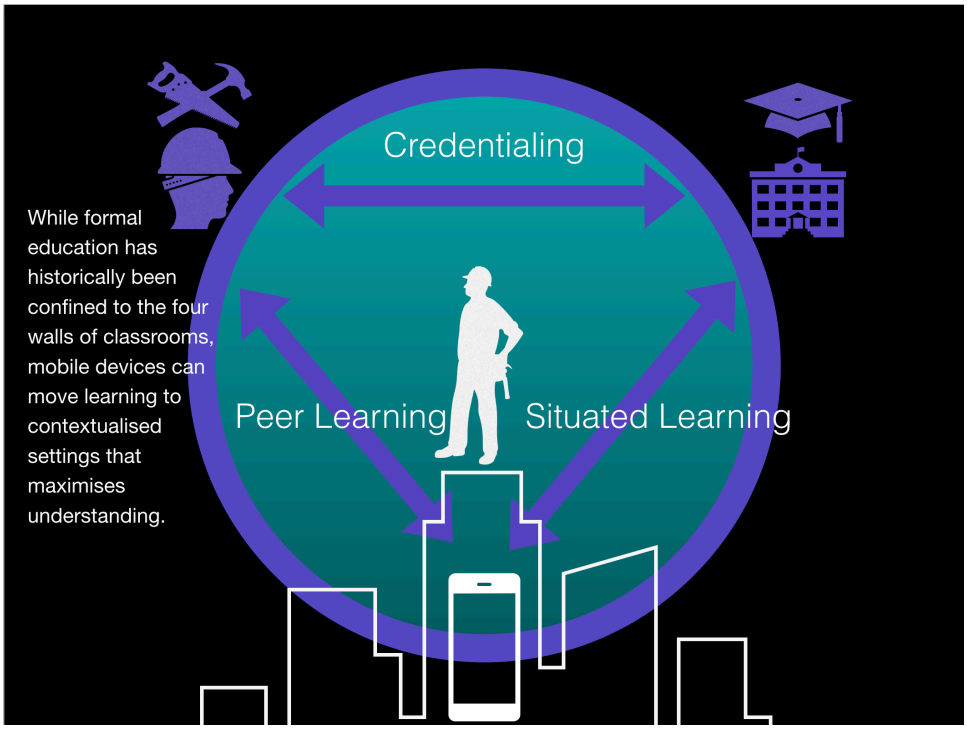


Figure 1: Components of Mobile Learning

Authentic learning environments:

- Provide authentic contexts that reflect the way the knowledge will be used in real life
- Provide authentic activities
- Provide access to expert performances and the modelling of processes
- Provide multiple roles and perspectives
- Support collaborative construction of knowledge
- Promote reflection to enable abstractions to be formed
- Promote articulation to enable tacit knowledge to be made explicit
- Provide coaching and scaffolding by the teacher at critical times
- Provide for authentic assessment of learning within the tasks (p. 18).

Learning Principles

- A learning experience for formative and summative assessment
- To create a more cohesive relationship between learners, facilitators, employers and other third parties.
- Ensure the app streamlines users work, not inhibit it.
- Ability for users to review course content and submit assessments contextually within a work environment or simulated work environment.
- Enabling work-site learning, and connecting it to real-life compliance actions/reporting

List of features/tasks

- Reimagine formal assessments (such as sustainability compliance) to suit informal, situated learning tasks.
- Set an assessment task remotely.
- Evidence learning tasks through the capacity to record photographs, video, audio and annotation. (Create an artefact)
- Curate the artefacts into a portfolio
- Send an artefact (Snapchat style) to a number of peers to obtain peer feedback
- Receive feedback (Voice thread style) from peers. (annotation, audio or video response)
- Submit the portfolio to mentor
- Credential participant at specific points through the learning experience such as peer and mentor interactions.
- For peer and mentor to rate (credential) the artefact.
- Locate artefacts geographically
- Digitally present portfolio into a formal education setting.
- Submit portfolio to formal education provider

Situated Learning

While formal education was historically confined to the four walls of classrooms, mobile devices can move learning to contextualised settings that maximises understanding. Situated learning can:

- Provide authentic context that reflect the way the knowledge will be used in real-life;
- Provide authentic activities;
- Provide access to expert modelling of processes;
- Provide multiple roles and perspectives;
- Support collaborative construction of knowledge;
- Provide mentoring and scaffolding at critical times;
- Promote reflection to enable abstractions to be formed;
- Promote articulation to enable tacit knowledge to be made explicit;
- Provide for integrated assessment of learning within the tasks.

Peer Learning

There is evidence that students learn a great deal by explaining their ideas to others and by participating in activities in which they can learn from their peers. Peer learning refers to students learning with and from each other based on the tenet that "Students learn a great deal by explaining their ideas to others and by participating in activities in which they can learn from their peers" (Boud, 2001).

Credentialing

Credentialing or badging is an effective method of motivating the learner in a mobile learning or game based context. "We are now seeing micro-credentialing, digital badging, e-portfolios and the proliferation of open source learning platforms. In this world, the design of a qualification is challenged, as are funding models, the role of institutions and the relationship between learning and credentialing." (Future of Australian Apprentices).

Games for Learning

A significant body of research demonstrates the efficacy of the use of games for learning (Randel et al., 1992; Wolfe, 1997). Huang (2011) found students gained confidence when they had learnt their subject through an online game. Hays' (2005) meta-analysis of studies found positive effects of games-based learning on students of all ages, including working adults. Vogel et al (2006) found greater levels of cognitive gain achieved through games-based learning regardless of discipline or student group. The games envisioned for this project fall into the category of what Abt (1987) termed 'serious games' – those intended to serve a purpose beyond entertainment. In this case the purpose is to produce social innovation or public good by maximising the uptake of LCL products and services.

Studies highlight many factors for consideration when designing games for learning. Admiraal et al. (2011) found that learning is assisted by interaction and the ability to measure individual progress and achievements against those of others. This finding lends support to this project's team-based approach to learning. Danforth (2011) studied 'World of Warcraft' players and the level of learning required to progress through the game. She found mastery through trial and error, and reward and feedback loops critical to player engagement, with the ability to address failure through learning being a key concept.

Similarly, Wu et al's (2012) meta-analysis of literature reviews on games, found that designs using learning theory achieved demonstrably better results. The design of games in this project is therefore underpinned by learning theory, particularly social constructivism (Vygotsky, 1978) as we seek to influence community as well as individual change.

Team-based Learning

The third body of research drawn on is team-based learning, or TBL, which is proven to increase motivation to engage with learning while also developing interpersonal and problem-solving skills (Michaelsen et al., 2002). Research on TBL suggests that groups should comprise five to seven people who bring a variety of skills and experience to the group. In addition, TBL activities should be structured to maximise the advantages of working together. As noted above, the combination of TBL and an element of gaming or competition, which are central to the learning design for this project, are highly effective means of motivating learners to engage, interact and progress.

Open Learning

One major source of inspiration for this research project is the phenomenon of Massive Open Online Courses, or MOOCs (Daniel, 2012; McAuley et al., 2010). MOOCs offered by Stanford University spin-off companies, Coursera and EdX, have proven that well-designed courses with expert content will attract thousands of participants. MOOCs generally use freely available Open Education Resources (OER), which significantly decreases costs (Siemens, 2005). A rich array of high quality OER on LCL is available for inclusion in this project's m-learning modules.

Another source of inspiration was the Global Corporate Challenge program, which aims to motivate people to improve their health through increased physical exercise (www.gettheworldmoving.com). This highly successful behavioural change program involves teams of workmates competing to walk a minimum of 10,000 steps each day and is underpinned by an interactive technology platform, downloadable to a smart phone, designed to inspire participants to commit throughout the program.

Learning Journey – Iteration 1

A first iteration of a learning design structure (learning journey) that incorporates the above elements of situated, peer based, open learning and gamification here and a link to the presentation made at the stakeholder meeting here. These learning design elements were against the learning needs, objectives and challenges of trades apprentices and builders in order to provide the stakeholder workshop with a mind-map of a learning process that could inform the final design brief for the M-learning platform. The stakeholders were encouraged to provide feedback on this process, and to comment on the value proposition for using such a platform from the point of view of their stakeholder groups. The process presented to the workshop described the initial ideas of how students would interact with an M-Learning App (Figure 2).

Initially, the student would first interact with a low-carbon construction skill-based learning model such as 'how to install double glazing'. The module could be developed by training body, VET, or TAFE institution. Once registered for the module, the student can perform learning tasks that are required to show competency. The mobile device allows the documentation or recording of that task in various ways using its built-in software, cameras and audio.

Once the task is complete the student can share the documentation with peers or class-mates, or to an instructor for feedback and comment or 'credentialing' before submitting the work or evidence for assessment. The assessed work can then be collated into a learning 'passport' or personal portfolio of evidence of acquired skills, and the ability to complete work in compliance with the NCC

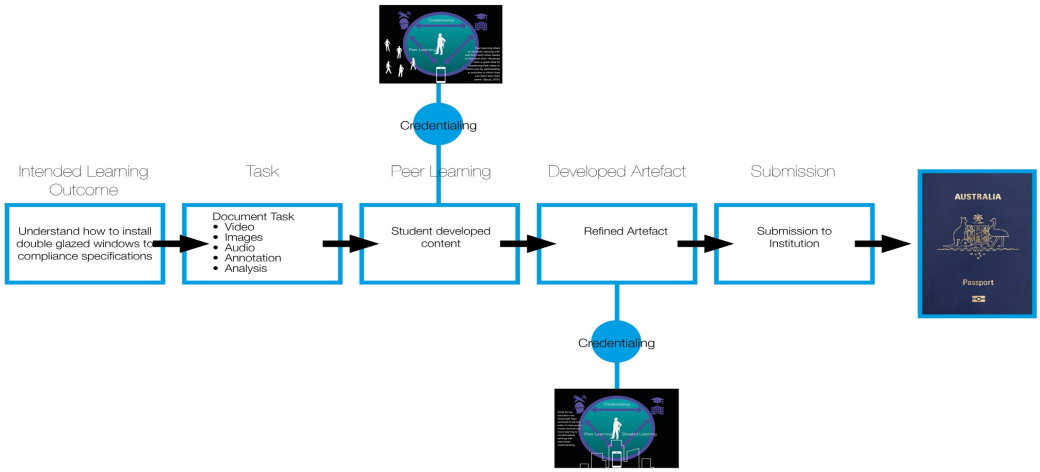


Figure 2: Learning Journey Iteration #1

Stakeholders felt that iteration one was likely to provide an engaging way for building trades learners to learn on-site, and opened up opportunities for students to follow progress on-site, and document compliant work as well as problems on building sites, and then take pictures or short videos that can be peer re-viewed before being included in assignments for assessment. However, they raised concerns about loss of productivity, and safety issues associated with promoting mobile phone use. Builders were also likely to not see any business value in having apprentices using the app on-site. The project team therefore decided to look not only at the learner's journey, but also the way in which the app could provide a service to builders. These issues were addressed in the development of the second Iteration of the learning Journey.

Learning Journey – Iteration 2

Based on the feedback from Iteration 1, the project team considered not only the learning journey, but also how builders, teachers and building surveyors might benefit from the M-Learning platform. For teachers, we focussed more on the on-site learning component, and how the tool could compliment, rather than duplicate full learning modules. The App also needed to be compatible with learning management systems being used by VET & TAFE institutions. The key for builders and tradespeople was to offer an opportunity to capture and catalogue the images taken by learners on site according to projects. This opens up the opportunity to gain a free record of compliant work being completed on their sites. In addition, the use of mobile phones by apprentices for learning, contributes to the construction workflow by providing documentation of work that can be submitted for inspections and approvals. The final catalogue of images for each project can also be vetted and compiled for quality management and marketing purposes. The cataloguing of construction work in this way also offers a benefit for building surveyors who may not always be able to physically inspect energy efficiency measures during construction.

Iteration 2 therefore introduced two paths (figure 3) – one 'credentialing' path for learner and teacher and a 'compliance' path for practitioners (Trades, Builders and Surveyors). The common element in each path is the image-based data compilation during the constriction process. For learners and teachers, this data is registered to the student via a student or course number. For the practitioners, the data is registered to each project via the building permit number. In each pathway the data is compiled into a 'Building Quality Passport' (BQP).

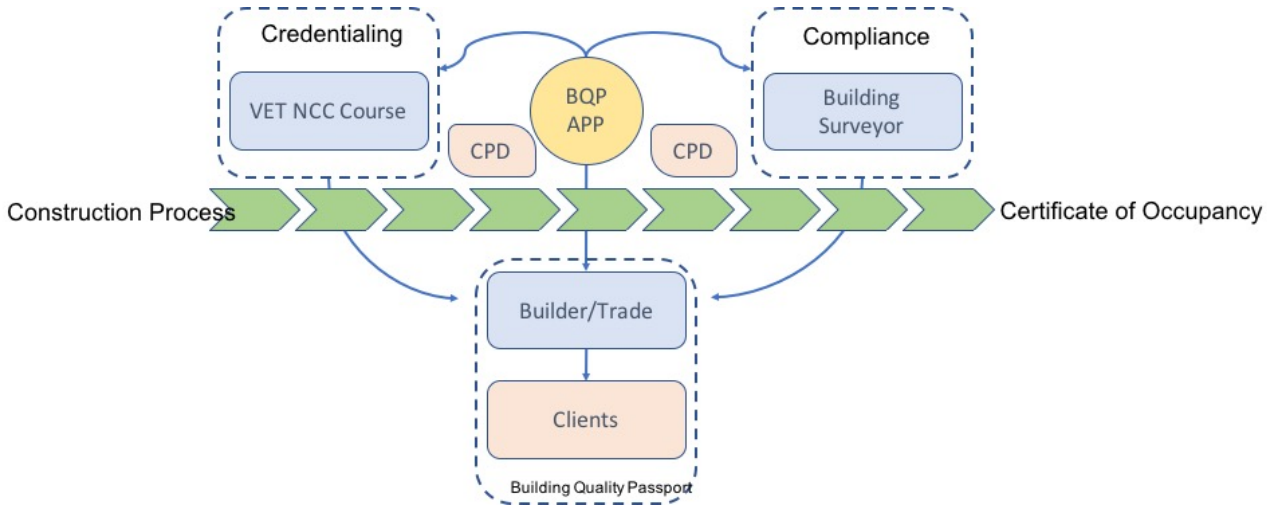


Figure 3: An on-site Assignment for Credentialing & Compliance: Building Quality Passport

Having clarified the learning design, the team could them move to the design of the M-Learning app itself. This required consideration of the user experience, and user's emotional goals.

Emotional Goals

It is widely argued that in designing most software applications much effort is placed upon the utilitarian goals (functional and quality goals), which make a software system useful. However, overlooking key drivers of engagement such as people's emotions and values, which cause a software system to be pleasurable to use, can result disappointment and system re- ejection depending upon the nature of the software system and emotional goals even if utilitarian goals are well implemented (Thaw and Sutcliffe,2017; Bentley, Johnston, and Baggy, 2002; Draper, 1999; Gouging, 1994; Hassenzahl, Beu, and Burmester, 2001; Krumbholz et al., 2000; Miller et al., 2015; Proynova et al., 2011). It is due to this fact that from the human perspective, what they would or would not like to feel (emotional goal) in some applications are just as much or more important than what a system is supposed to accomplish (Callele, Neufeld, and Schneider, 2006; Bahsoon, Emmerich, and Macke, 2005). As a result, in the process of adoption and appropriation of a software, stakeholders are demanding software that is more than just functional. They do not perceive a set of individual features in isolation but instead evaluate the entire experience including their perception of the system at an emotional level (Petermann, 2013).

Consequently, if a software system is unable to attract users, appeal to their emotional needs, a likely consequence is that people will not adopt it, it fails and often leads to users frustration (Van Harmelen, 2001; Platt, 2007; Dix et al., 2003; Brooks, 1987; Shneiderman et al., 2016). It is therefore important to take into account people's goals that will create a desire to engage with the system (as opposed to the fear of not completing a particular work task). These goals may be related to social values or emotions that people wish to feel (Sutcliffe and Thew, 2010; Miller et al., 2012). From this perspective, considering people's emotional goals is important as a transition in software design practice from useful, usable, and satisfying design to effective, efficient, and gratifying design.

In such situations, the main design challenges are not just technical but also are driven by social and cultural needs to engage people at an emotional level (Gogueny, 1994; Clancy, 1995; OASIG, 2015; Whittaker, 1999; Tichy and Bascom, 2008; Gonzales and Leroy, 2011). Accordingly, overall software quality is reduced when people's emotional goals are not incorporated into the software design process (Guinan and Bostrom, 1986; Dieste, Juristo, and Shull, 2008; Gonzales and Leroy, 2011; Colomo-Palacios et al.,2010).

It is our argument that without a proper method for analyzing people's emotional goals to define software specification, efforts may not be led to action. For this reason, a technique for analysing emotional goals and con- verting them into something that can be analysed by existing software engineering methodologies is necessary for system prototyping, verification, validation, and final implementation.

For this purpose, one of the PhD projects proposed a method by combining the theories and techniques of software engineering, requirements engineering and decision making, to ensure people's emotional goals include right from the beginning of the software development life-cycle. The contribution of this study is a technique entitled Emotional Goals Systematic Analysis Technique (EG-SAT), which provides an approach to facilitate the process of finding software system capabilities to address emotional goals in software design. The EG-SAT is a systematic technique that instead of focusing just on visualizing people's emotional goals can help to provide system analysts with insights on how to address people's emotional goals. This technique facilitates addressing emotional goals in the software design process by converting emotional goals into functional and non-functional goals, that can be analysed by existing software engineering methodologies. As the outputs of the EG-SAT (i.e.: functional and non-functional goals) are represented in a hierarchical structure, the EG-SAT can be used for tracing back system's capabilities and find whether people's emotional goals have been addressed by system's specifications or not. The EG-SAT offers a process- oriented approach for analysing emotional goals in a systematic, coherent and integrated way while this encouraging insight and creativity. It is also flexible to adopt any changes in terms of identifying new emotional goals during the system development process.

The EG-SAT aims to provide the right level of constraints to guide the pro- cess without overly constraining creativity. Instead of focusing just on visualizing people's emotional goals, the proposed method in this study pre- serves the traceability of emotional goals through to the design features that support them. The proposed method is flexible to adopt any changes in terms of identifying new emotional goals during the system development process.

Figure 4: An on-site Assignment for Credentialing & Compliance: Building Quality Passport

Emotional Goals Systematic Analysis Technique

In developing the proposed method we used the main idea and principles of FAST in developing our proposed method. Although this study is not entirely based on the FAST, we adopt the main idea of 'How' and 'Why' questions used in the FAST. This approach helps this study to take advantages of FAST in an attempt to analyse people's emotional goals. In addition to FAST's main component (i.e. Function), in this study we added another two other components including quality and emotional goals and suggested Emotional Goals Systematic Analysis Technique (EG-SAT). The EG- SAT aims to provide a guideline to system analysts in finding functional and quality goals in order to address emotional goals. The EG-SAT enables system analysts to deal with the complexity of emotional goals analysis.

In developing the proposed method, we adopt the notation proposed by Sterling and Taveter (2009), shown in Figure 1.1. The heart, cloud and parallelogram shapes represent the emotional, quality and functional goals respectively. These notations refer to the following definitions:

- **Functional Goal:** what people expect a software system should or should not do.
- **Quality Goal:** what people expect a software system should or should not be.
- **Emotional Goal:** what people would or would not expect to feel by using a software system.

To understand these definitions better, let's consider a social application like Facebook™. The goal of connecting friends is a functional goal that is quite different from the emotional goal of feeling connected. However, the functionality that connects friends supports a feeling of connectedness.

The EG-SAT promotes a hierarchical structure linking high-level emotional goals to more detailed emotional goals or functional and/or quality goals. In the EG-SAT hierarchy, any high-level emotional goal can be fulfilled by satisfying functional and/or quality goals in the next level of the hierarchy. Figure 1.2 represents a schematic view of the EG-SAT hierarchy. Each descending level in the EG-SAT hierarchy represents an increasingly-detailed description of the emotional, functional and quality goals. Functional and quality goals in the lower layers represent the high-level solutions that ad- dress emotional goals.

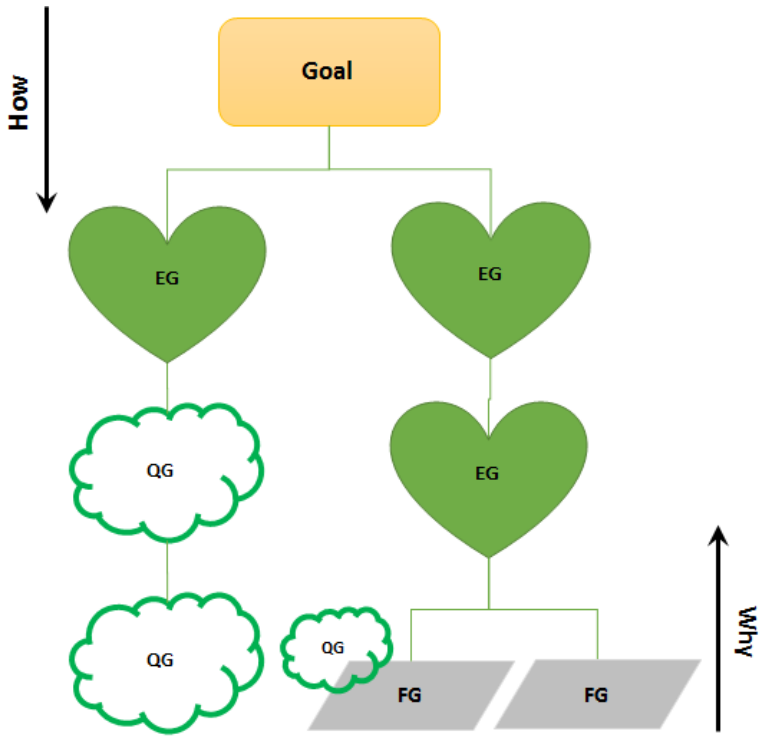


Figure 5: Schematic View of EG-SAT Hierarchy

The attached quality goal to the functional goal in Figure 1.2 shows that functional goals may be supported by quality goals. The 'How' and 'Why' arrows in Figure 5 — as we will discuss in detail in the following section — show the direction of analysis of emotional goals in the EG-SAT. Each layer must contain all the goals (i.e. emotional, functional

and quality) needed to en- sure stakeholders achieve the next higher-level goals. This prevents extra goals that do not address emotional goals. Through the hierarchical structure of the EG-SAT, system analysts can always trace back to an emotional goal for specific functional and quality goals, meaning that the EG-SAT can be used for tracing the system capability in addressing people's emotional goals.

Process Model

One of the main purposes of proposing the EG-SAT in this study is developing a technique for helping system analysts to analyse people's emotional goals and breaking them down into the key functional and quality goals. For this purpose, in this section, we outline a process model for analysing emotional goals by using the EG-SAT. As shown in Figure 6, the input to the process model is a list of emotional goals, which can elicited using any technique such as the EAF (Sherkat et al., 2018), POSE (Miller et al., 2015), ethnography (Neuman, 2005), etc. What makes these methods different from others is not only the processes and techniques that they use for emotional goals elicitation but also the context in which emotional goal elicitation technique is employed. For instance, in the EAF emotional acquisition process (Sherkat et al., 2018), emotional goal elicitation process adapts to the meta-concepts that the elicitation framework introduces. In the POSE (Miller et al., 2015), a quite different and simpler meta-model based on the ethnography is used. Regardless of the elicitation method, this activity en- compasses what stakeholder would or would not like to feel by using a software system.

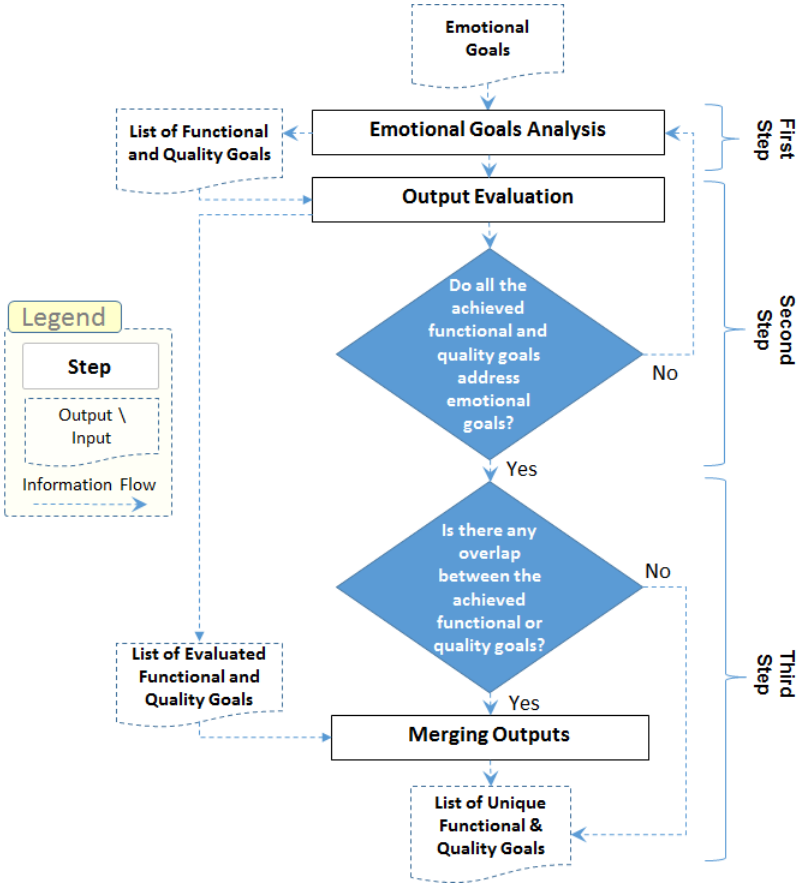


Figure 6: The EG-SAT Process Model

The output of the EG-SAT is a list of functional and quality goals that sup- port the emotional goals. These functional and quality goals will vary based on system analyst's expertise and the project context. As shown in Figure 6, the EG-SAT process includes the following steps: (1) emotional goal de- composition and analysis; (2) functional and quality goal appraisal; and (3) functional and quality goal consolidation.

Step 1: Emotional Goal Decomposition and Analysis

Table 3: Emotional Goal Decomposition and Analysis

Task	Input	Technique	Output	Terminating Condition
Decomposition & Analysis	Emotional Goals	EG-SAT (*'How'* question)	List of Functional and Quality Goals	Achieve at least one relevant functional or quality goal for each emotional goal

The first step aims to help system analysts to find a set/series of functional and/or quality goals for addressing the emotional goals.

The first step aims to help system analysts to find sets of functional and quality goals for addressing the emotional goals. This starts by listing elicited emotional goals at the top of the EG-SAT hierarchy. The EG-SAT vertical hierarchy helps macro analysis of emotional goals until the key functional and quality goals for addressing emotional goals be identified. For this purpose, system analysts start asking the 'How' question that primes the analyst for getting down to a solution (Berger, 2014). This line of questioning and thinking is read from top to bottom. Asking this question in the EG-SAT helps system analysts to get down to functional and quality goals that can be used for addressing emotional goals. A 'How' question may be answered by functional goals, quality goals, or even other emotional sub- goals. It should be answered from the viewpoint of different stakeholders to capture their perspectives and create a variety of ideas.

Emotional goals that are first elicited are usually high-level objectives. It means that if system analysts want to analyse abstract/combined emo- tonal goals, they should first refine/decompose them to have sufficient detail for further analysis. In the case of having an abstract/combined emotional goal, the 'How' question decomposes an emotional goal into a set of alternative emotional sub-goals such that satisfaction of one or all of them leads to the satisfaction of original emotional goal. Accordingly, there are two decomposition cases; (I) AND-decomposition: when every emotional sub-goal needs to be satisfied for the original emotional goal to be satisfied; and (ii) OR-decomposition: when the satisfaction of one emotional sub- goal is sufficient for the satisfaction of the original emotional goal. Figure 1.4 shows sample AND and OR decompositions.

For answering the 'How' question, different creative problem-solving techniques such as Brainstorming methods (Gallagher, 2013), the Systematic Inventive Technique (Goldenberg, Lehmann, and Mazursky, 2001), or the Theory of Inventive Problem Solving (TRIZ) (Altshuller, 1996) can be used. In this step, it is important to avoid judgmental thinking as it constrains the initial creative process. What is important in asking the 'How' question is that possible answers should identify what is to be designed and not how it is to be implemented. In other words, the 'How' question determines how to fulfil the emotional goals with functional and quality goals, but not necessarily how these functional and quality goals should be exactly implemented in the software engineering process.

Asking the 'How' question for each emotional goal should be continued until at least one functional or quality goal is achieved and system analysts are satisfied that a relevant functional or quality goal is identified. In other words, the termination condition of asking the 'How' question is when there are no (sub-) emotional goals at the bottom of the EG-SAT hierarchy. This is because emotional goals are properties of people, not software, so cannot be implemented directly.

As an example, the possible answer for 'How can sense of completion be ad- dressed in a learning application?' would be a functional goal like "Documenting Learning Achievement", "Credential Acknowledgement" and, "Giving Feedback". These functional goals can be implemented in different ways and through different software specifications and would require significant further analysis. Asking the 'How' question helps system analysts to avoid thinking just about a technical feature and miss the opportunity to engage in divergent thinking about other alternatives that can be used for addressing emotional goals. Figure 1.5a shows the EG-SAT hierarchy for a sample emotional goal.

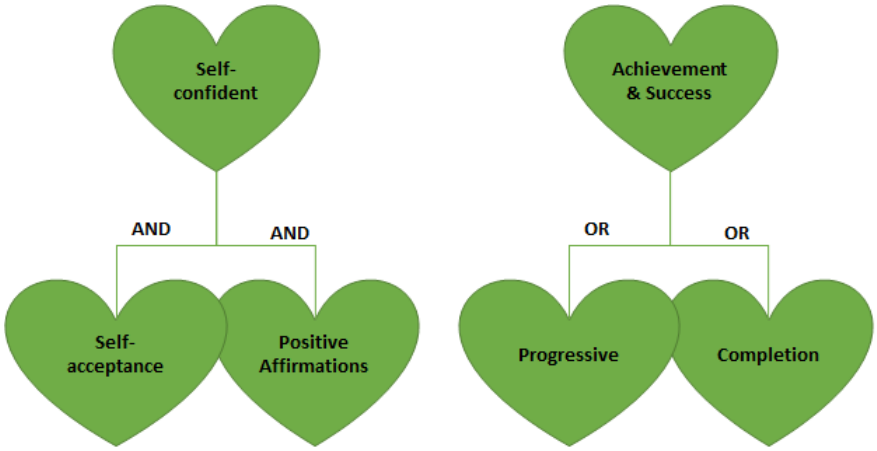


Figure 7: Sample of AND and OR decomposition

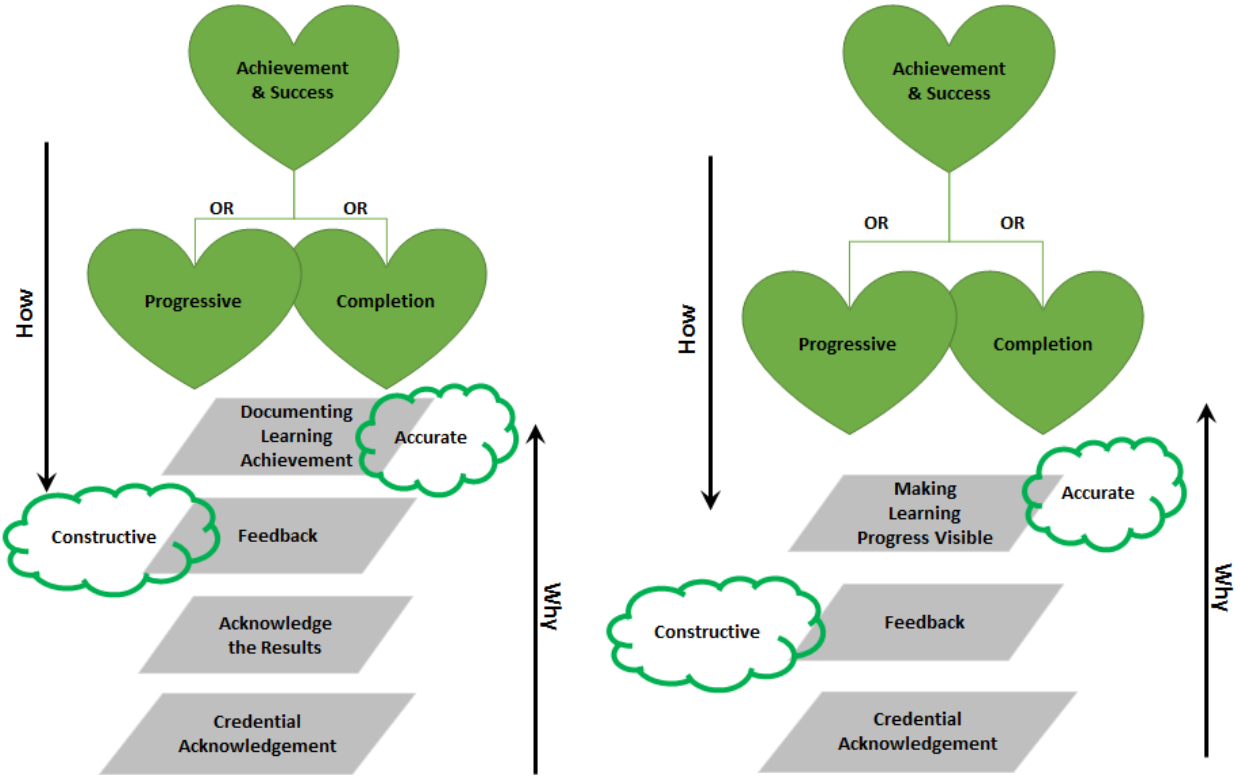


Figure 8: Sample of How Question analysis (Left) and Merging Goals (right)

Step 2: Functional and Quality Goal Appraisal

Table 4: Functional and Quality Goal Appraisal

Task	Input	Technique	Output	Terminating Condition
Appraisal	List of Functional & Quality Goals	EG-SAT (*'Why'* question)	List of Evaluated Function & Quality Goals	Functional & Quality Goals are Relevant & Suitable

The second step aims to help system analysts to evaluate the achieved functional and quality goals and makes sure that they are relevant and address the emotional goals. In the first step, answering the 'How' questions, analysts should avoid judgmental thinking. In the second step, we answer 'Why' questions. This line of questioning is bottom-up and should switch from creative to critical thinking. 'Why' questions are interrogative questions whose primary goal is to help system analysts understand which functional and/or quality goals do not address the related emotional goal and should be eliminated or improved. This is an iterative process and can be repeated several times until the systems analyst is satisfied with the correctness of all of the achieved functional and quality goals. As an example, we use the EG-SAT hierarchy discussed in the previous step (Figure 1.5a). The possible answer to Why is "credential acknowledgement" necessary? Is "because this functionality can help learners to see that they have completed learning tasks to a particular point".

The 'Why' question can also be used for tracing functionality back to emotional goals. In other words, the 'Why' question can be used as a traceability technique to determine which users' emotional goals can be addressed by the existing system's specifications.

Step 3: Functional and Quality Goals Consolidation

Table 5: Functional and Quality Goals Consolidation

Task	Input	Technique	Output	Terminating Condition
Consolidation	Evaluated Functional & Quality Goals	Combination	List of Non-repetitive Functional & Quality Goals	No Repetitive Goals

The third step produces a list of non-repetitive functional and quality goals by asking whether there is any overlap between the proposed functional and quality goals. Consolidation is defined as an operation that combines two or more similar functional or quality goals. This occurs when two or more goals represent the same main concept. For this purpose, once the previous steps are complete, system analysts begin to group and consolidate similar functional and quality goals. As an example, "Documenting Learning Achievement" and "Acknowledging the Results" are two functional goals that have been achieved and evaluated in the first and second steps respectively. However, both of these functional goals refer to the same concept, "Making Learning Progress Visible". Accordingly, we can merge these two functional goals and replace them with a non-repetitive goal in the EG-SAT hierarchy (Figure 1.5b). Combined functional goals inherit their associated quality goals to the new functional goal resulting from the consolidation process.

Summary

Table 6: The Summary of Evaluation Techniques

Evaluation Goal	Evaluation Method	Evaluation Criteria	Coverage	No.
Effectiveness	Case Study & Semi-controlled Experiment	Completeness, Correctness & Consistency	Domain experts Educators & apprentices Software engineers	7 17 12
Efficiency	Semi-controlled Experiment	Time Perceived Ease of Learning Perceived Ease of Use Perceived Usefulness Intention to Use	Software engineers	12

In summary, in the EG-SAT, each emotional goal will be analysed until it reaches specific functional and/or quality goal. The main focus of the pro- posed method is supporting the ideation process for addressing emotional goals. This method in this research is incremental and iterative so system analysts may switch between tasks as new ideas emerge. The lower level in EG-SAT shows functional and quality goals that the system analysts have more control over and can be used by system analysts for further analysis via existing software engineering methodologies.

Implementation

Method

After eliciting emotional goals, we led the application of the EG-SAT to analyse the emotional goals of trainees and apprentices in the building sec- tor in Australia for designing the Building Quality Passport that fulfilled the elicited emotional goals.

Emotional Goals

The first step was to find the list of emotional goals for the application to serve as input to the EG-SAT. To gather sufficient data for analysis, three different questionnaires were used with 16 participants including 11 building and trades trainees and apprentices, two employers and workplace mentors and, three training facilitators and trade teachers. The online questionnaires were focused on trainees and apprentice's emotional goals for designing a mobile learning application entitled Building Quality Passport.

Table 7: Summary of Emotional Goals in Building Quality Passport

ID	Emotional Goals	Sub-emotional Goals	Frequency	Attachment Driver
IP1-1	Freedom and Flexibility	Sense of learning at my own pace	4	Ideological Pleasure
IP2	Sense of time efficiency	–	4	Ideological Pleasure
IP3	Sense of trust in the information	–	4	Ideological Pleasure
PP1	Sense of reality	–	4	Physical Pleasure
IS1	Knowledgeable and Skillful	–	3	Ideal Self
PS1	Professional	–	3	Public Self
PS2	Qualified	–	3	Public Self
AF1	Connected	–	3	Affiliation
SP1	Support and Assisted	–	3	Social Pleasure
IS2-1	Self-confident	Prepared	2	Ideal Self
IS2-2	Self-confident	Sense of contribution	2	Ideal Self
IS3	Sense of opportunity	–	2	Ideal Self
IS4	Sense of monetary (wealth)	–	2	Ideal Self
AF2	Sense of networking	–	2	Affiliation
IP4	Sense of cost-effectiveness	–	2	Ideological Pleasure
SP2	Sense of promotion & progression	–	2	Social Pleasure
IS5	Sense of being cutting edge	–	1	Ideal Self
IS6-1	Sense of achievement & success	Progressive	1	Ideal Self
IS6-2	Sense of achievement & success	Sense of ongoing learning	1	Ideal Self
IS6-3	Sense of achievement & success	Sense of growing strength	1	Ideal Self
IS6-4	Sense of achievement & success	Sense of completion	1	Ideal Self
IP1-2	Freedom and Flexibility	In control	1	Ideological Pleasure
PP2	Sense of fun	–	1	Physical Pleasure
SP3	Sense of competition	–	1	Social Pleasure

In each questionnaire, a series of general questions were asked, based on the following themes: 1) what should a mobile learning application do for you?; 2) how should it be?; and 3) how do you want to feel when using a mobile application for learning purposes? These questions were not asked directly as stated above but were based on these themes. For those participants with experience in using mobile learning applications, also some questions were asked regarding problems they experienced using mobile learning applications. The data was analysed to extract and model the key emotional goals of different stakeholders.

As a result, 56 emotional goals were elicited. Based on the similarity between the achieved emotional goals, we consolidated similar emotional goals to achieve a list of non-repetitive emotional goals. In this study, the 56 initial emotional goals were grouped into 24 non-repetitive emotional goals. Table 7 represents a summary of results. The fourth column in Table 7 represents the frequency of each emotional goal; for example, four different emotional goals in the data had the same emotional concept of 'learning at my own pace'. This indicates higher importance and priority. By analysing the online survey data we categorized the achieved emotional goals under the four main emotional drivers. Figure 9 shows the related emotional attachment drivers for each emotional goal.

From Table 7 we can understand some useful facts that can help the us to contextualize the emotional goals in designing Building Quality Passport App. For instance, according to the distribution of emotional goals in Table 7 we can infer that trainees and apprentices in the building sector would like to feel that they are able to learn at their own pace. The time efficiency is another important factor that trainees and apprentices would like to feel in using any learning application. Due to the technical sensitivity and high level of responsibility in the building sector, any learning application should deliver accurate information to the learners. The high frequency of 'Sense of reality' in the achieved data also indicates that trainees and apprentices would prefer using a learning application that brings them real-work experience. As Table 7 shows, the Ideal Self is an important driver for forming the emotional attachment between trainees and apprentices and a mobile

learning application. In other words, the majority of the trainees and apprentices emotional goals can be addressed by considering features and capabilities in a mobile learning application that help users to increase their employability skills and doing their job well.

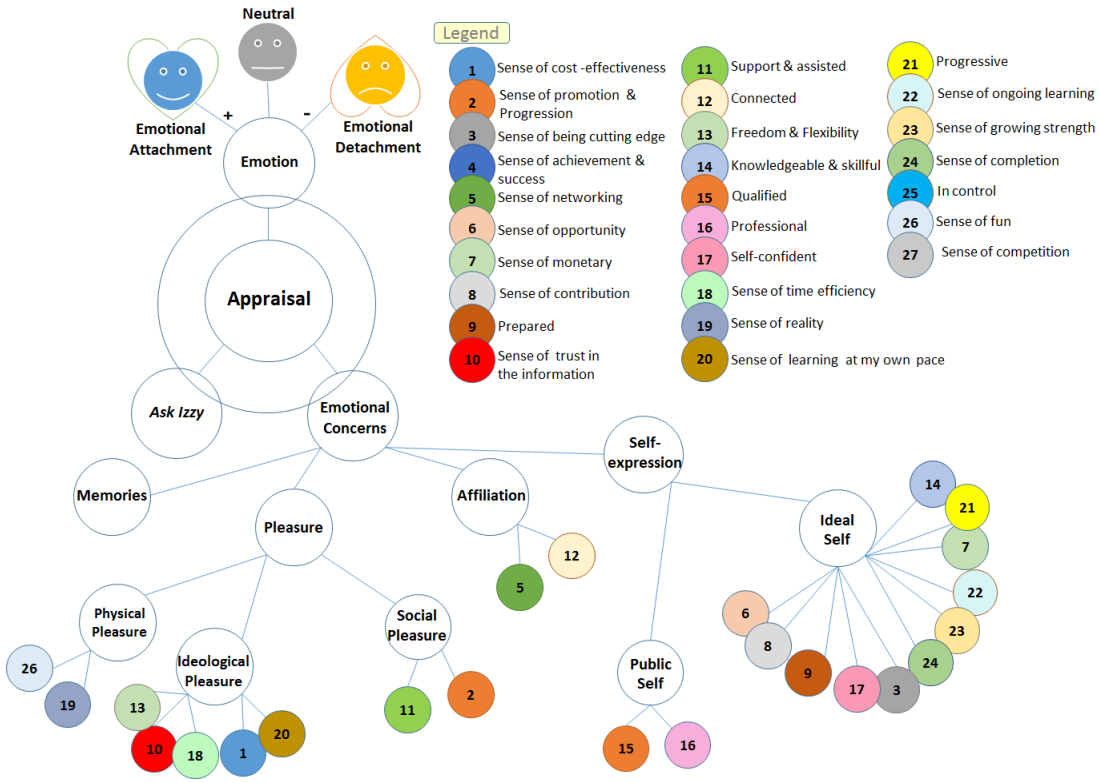


Figure 9: Building Quality Passport Emotional Goals and Attachment Drivers

EG-SAT Application

We analysed the set of emotional goals using our EG-SAT process model (Figure 6). As a result, 17 'Quality Goals' and 21 'Functional Goals' were achieved for addressing the emotional goals. From Table 6 we can see that the emotional goals associated with 'Ideological pleasure' are predominantly addressed by a series of 'Quality Goals'. However to satisfy other emotional goals, 'Functional Goals' are more effective. Among all the achieved functional goals, 'Networking' is the most repetitive functional goal for addressing the emotional goals.

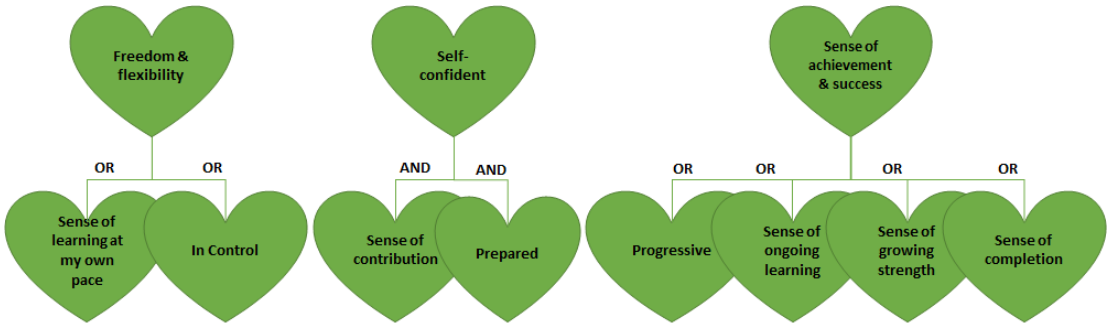


Figure 10: Sample of Emotional Goals Decomposition - Building Quality Passport

We then conducted internal brainstorming sessions to find some detailed design solutions (software features) for each functional and quality goal and used the results to design a digital prototype for the Building Quality Passport.

Results

In Figure 11 we summarized the trainees and apprentices emotional goals in the Building Quality Passport case study and associated drivers that influence their emotional attachment to the Building Quality Passport (The complete screenshots of designed digital prototype is available at https://tinyurl.com/y8m9sl72).

The EG-SAT provides the advantage of the FAST technique including (I) preparing the middle-level creativity for analysing people's emotional goals and, (ii) higher capability to generate novel ideas. The EG-SAT also com- prises a unified approach to analyse people's emotional goals alongside the functional and quality goals to bridge the gap between emotional requirements engineering and design action.

By using our proposed method in designing the digital prototype of Building Quality Passport, we analysed 24 high level emotional goals under the four main emotional themes: 1) Self-expression; 2) Affiliation; 3) Pleasure; and 4) Memories. After analysing the emotional goals by using the EG-SAT, 20 functional and 17 quality goals were achieved (Table 8). In the analysis process, the hierarchical nature of the EG-SAT allowed us to focus on the highest-level emotional goals and then drill them down into functional and quality goals.

Figure 12 shows the results of the EG-SAT analysis. The black circles in the diagram represent the hyperlink points. Whenever grey circles are seen, the related black circles must be followed. As Table 8 shows, 17 'Quality Goals' and 21 'Functional Goals' were achieved for addressing the emotional goals. From Table 8 we can see that the emotional goals associated with 'Ideological pleasure' are predominantly addressed by a series of 'Quality Goals'. However to satisfy other emotional goals, 'Functional Goals' are more effective. Among all the achieved functional goals, 'Networking' is the most repetitive functional goal for addressing the emotional goals.

Table 8: Summary of EQ-FAST Analysis in Building Quality Passport Case Study

Emotional (Sub-emotional) Goal	Proposed Quality Goals	Proposed Functional Goals	Comment
Freedom and Flexibility (Sense of learning at my own pace) (In control)	Repeatability, Modularity, Flexible	–	–
Sense of time efficiency	Short and Sharp, Easy to understand, Reusable Contents, Compatibility / Integrity	–	–
Sense of trust in information	Accurate Content, Reliable Platform	–	–
Sense of reality	–	Simulation, Case-based learning	–
Knowledgeable & Skillful	Tangible	–	Refer to " Sense of reality"
Professional	–	Represent Experiences and Skills, Represent Certificates and Qualifications, Like and Follow, Represent Badges & Rewards, Represent Progress, Networking	Refer to "Sense of networking" & "Connected"
Qualified	–	Represent Experiences and Skills, Represent Certificates & Qualifications, Like & Follow, Represent Badges & Rewards, Represent Progress, Networking	Refer to "Sense of networking" & "Connected"
Connected	–	Networking	–
Supported and assisted	Easy to find, Instant	Resource, Instructor Feedback	Refer to "Sense of Networking" & "Connected"
Self-confident (Sense of contribution) (Prepared)		like and follow	Refer to "Sense of Achievement and Success", "Connected", "Sense of Networking", "Supported and Assisted" "Professional" and " Qualified"
Sense of opportunity	–	Estimator (Current position, market demand, wealth generation)	–
Sense of monetary (wealth)	–	–	Refer to "Sense of Networking" & "Connected", "Professional" & "Qualified"
Sense of achievement & success (Sense of ongoing learning) (Sense of completion)		Benchmarking, Assessment/ Grading, Goal Planning, Makes progress visible (Progressive) Credentialing Acknowledgement, Offer Badges & Reward	Refer to "Professional" & "Qualified"
Sense of networking	–	Networking & Peer Feedback	–
Sense of cost-effectiveness	Reusable Contents	–	–
Sense of promotion & progression	–	Make progress visible, Benchmarking, Assessment/ Grading, Credentialing Acknowledgement, Offer Badges and Reward	Refer to "Professional" & "Qualified"
Sense of being cutting edge	–	Track & Trace Technology News, Technology Statistics and history of use	Refer to "Professional" & "Qualified"
Sense of fun	–	Gamification	–
Sense of competition	–	Make progress visible, Benchmarking, Assessment/ Grading, Credentialing Acknowledgement, Offer Badges and Reward	Refer to "Sense of Fun"

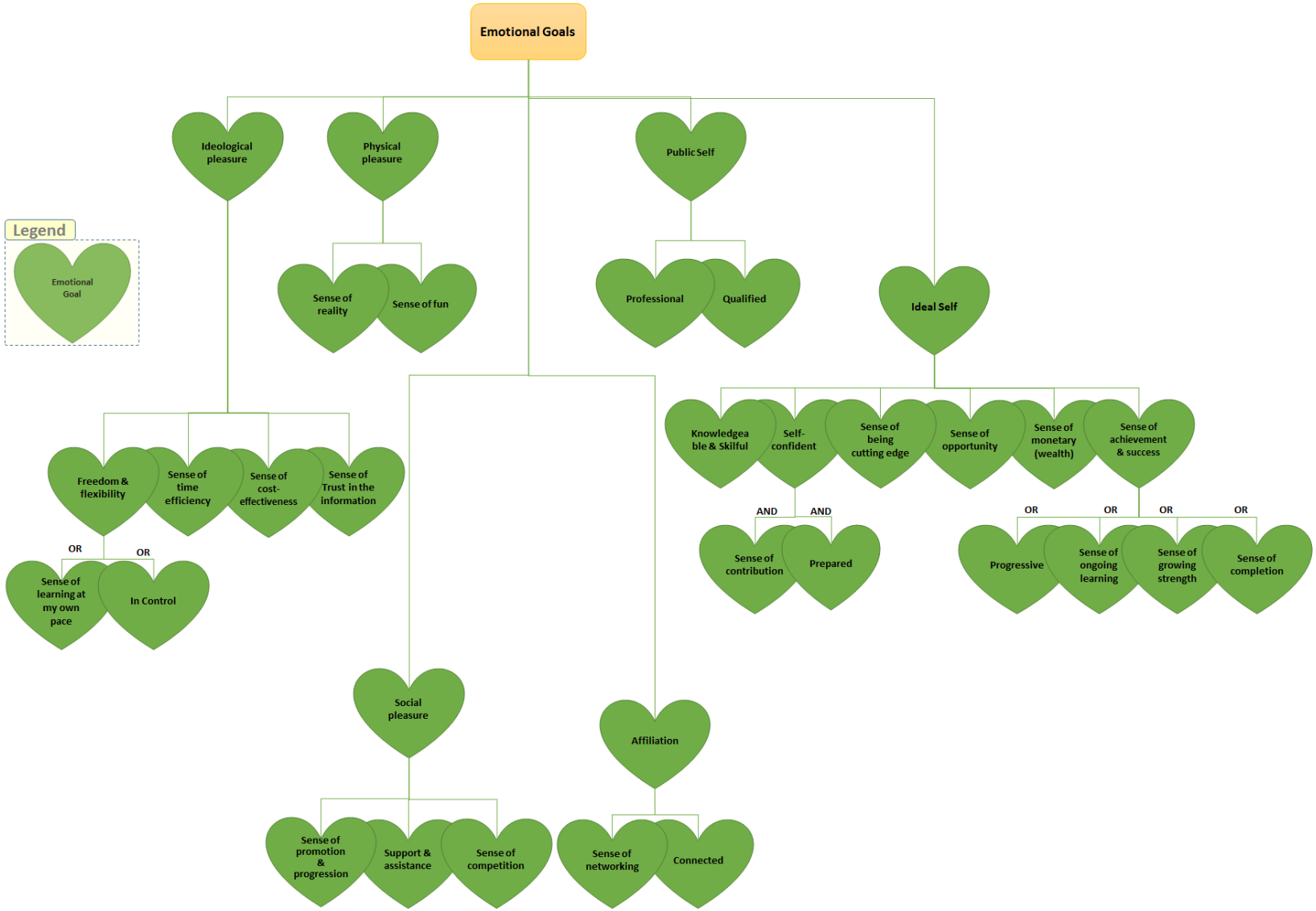


Figure 11: Building Quality Passport Emotional Goals and Attachment Drivers
(A high-resolution image is available at https://tinyurl.com/y7wtdgbn)

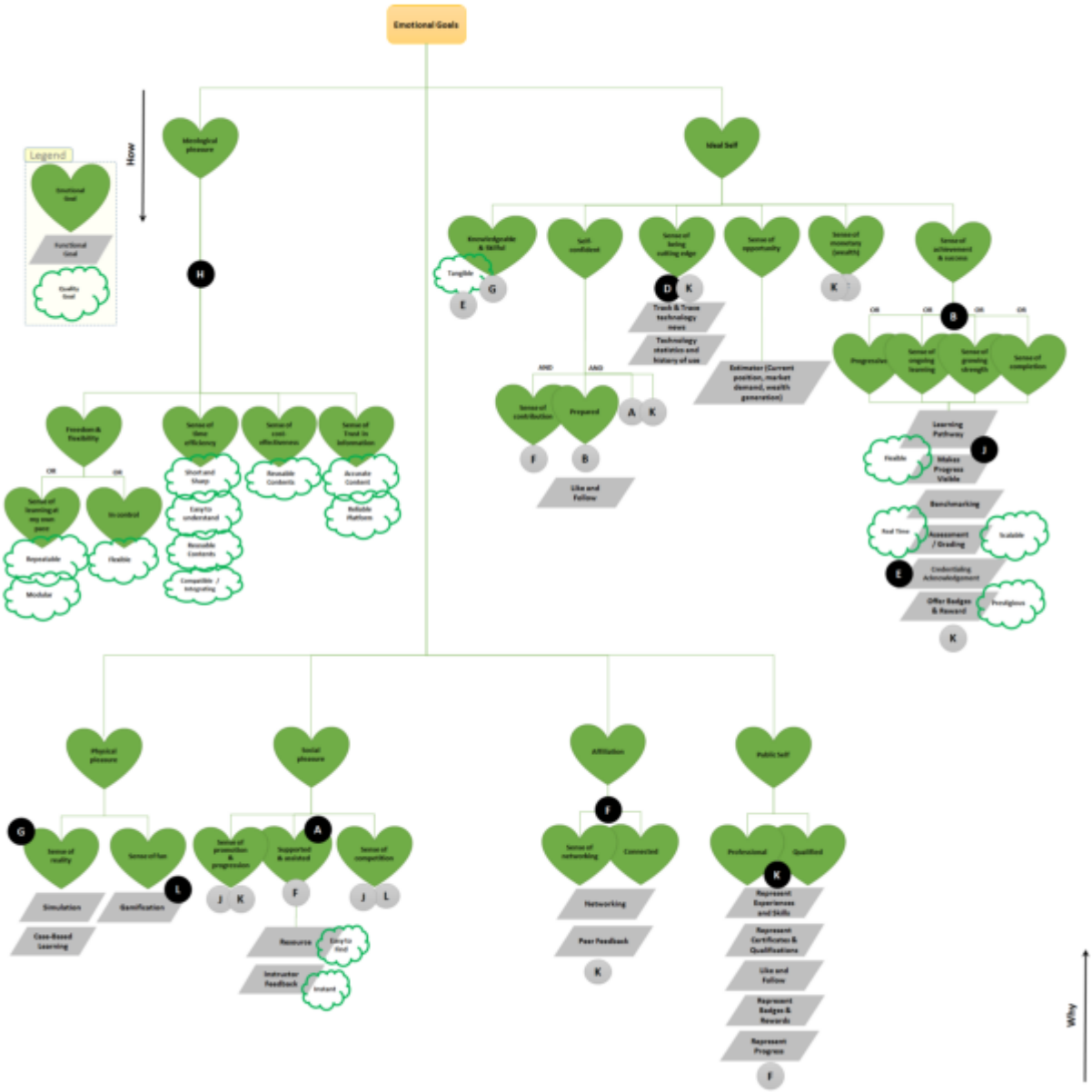


Figure 12: Building Quality Passport EG-SAT Analysis (A high-resolution image is available at https://tinyurl.com/y842zja6)

Table 9: List of Emotional Goals - Building Quality Passport

Feel earn money through the qualification	Feel linked
Feel save money	Feel not intimidated by classroom environment
Feel save time	Feel career opportunities
Feel ongoing learning	Save time or money
Feel on the job access	Feel visual mechanisms
Feel visual learning prompts	Feel it real
Feel privacy	Feel happy learning
Feel engage at my own pace	Feel competition
Feel not feel 'dumb' if I don't keep up with the class	Feel real on the job examples
'show me' rather 'tell me' approach	Feel realistic
Feel natural learning styles	Feel knowledgeable
Feel not being bombarded	Feel value
Feel not information overload	Feel honour
Feel managed	Feel respect
Feel cheap to engage	Peer recognition
Feel consistency	Direct link to job outcome
Offline – online	Real life examples
Feel connected	Repetition through ongoing voluntary engagement
Feel ongoing	Review and learn at my own pace
Feel successful	Feel not overwhelmed
Feel mature	Feel self-esteem
Feel on the job access	Increased comprehension
Feel intimacy	Feel engaged
Can watch / engage at their own pace	Feel job related
Feel simple	Feel qualified
Feel confusion	Feel capable
Feel data control	Feel growth
Feel costly to engage	Feel trustable

The User's Personas

Having analysed the functional, learning and emotional goals of target users, we were able to develop the following 'personas' which prove an essential description of the performance that the app should deliver. These became the reference points for refining the design of the building quality passport.

Mary Learner

Profile	Location	*Australia*
	Occupation	*Building / Construction Learner*
	Age	*30*
	Marital Status	*Single*
BEHAVIORS	Lifestyle	*Socially active but not obsessed, prefers action to talk, expects ease of use as baseline, watches 2 hours of TV via web & iPad apps, proficient across many digital devices*
	Description	*One of the few female learners in the class. Enjoys the interaction aspect of learning and worksite practice. Struggles to keep on top of submitting completed tasks and want's to be able to submit on the go. Finds it hard to remember what she learned at TAFE / all the nuances of the building code and what applies to which situation.*
	Interests & Hobbies	*Spends time with friends, going to restaurants, hiking, working out at the gym*
	Technology Use	*Technology has been a part of lifestyle since teen years. Uses multiple devices (mobile, tablet and laptop), though the mostly phone.*
NEEDS	Usage Goals	*She wants want to be able to submit course tasks on the go. She expects us to help her make it happen.*
	Emotional Goals	*"I would like to have a sense of reality in off-the-job learning" "Instead of formal learning style, I am looking for flexible, effective and efficient learning option",*
	Motivations & Triggers	*Have Fun*

John Teacher

Profile	Location	*Australia*
	Occupation	*TAFE Teacher*
	Age	*45*
	Marital Status	*Married*
BEHAVIORS	Lifestyle	*Reading e-books and watching TV documentaries. Does not use digital devices for fun and relaxation.*
	Description	*John is an experienced builder who for the last 7 years has taught Cert IV Building at Swinburne TAFE. John feels a sense of responsibility for his students welfare while on site and is passionate about ensuring they have all the available information in order for them to make safe, informed decisions. He struggles at times to keep on top of checking the students work and wants some way of collating all his students and their work into one system. Will speak with students employers every now and then, but it's mainly to follow up on his students submitting work.*
	Interests & Hobbies	Loves photography. It has taught him to be patient and observing.
	Technology Use	*Most of Johns time (if not in the classroom) is spent on a laptop at a desk where he can respond to student queries, assess work, etc. He has a phone but rarely uses it for work purposes as at this stage there's no real need. Doesn't own or use a tablet but isn't against the idea if it can help streamline his workflow.*
NEEDS	Usage Goals	Ensure students have ability to access course / code information, Ensure students understand course content and are able to demonstrate skills safely, Streamline workflow
	Emotional Goals	*"I would like to have a sense of control and monitoring in on-the-job learning" "I would like to have a better relationship with my students"*
	Motivations & Triggers	*Sense of effectiveness*

Steve Mentor

Profile	**Location**	*Australia*
	Occupation	*Builder*
	Age	*40*
	Marital Status	*Married*
BEHAVIORS	**Lifestyle**	*Traveling and connecting with new folks outside of building industry.*
	Description	*Steve has worked for himself for 12 years. Throughout this time he's had four apprentices, getting sub contractors when he needs to - but tries to avoid it if possible. As it's usually only him and the apprentice most of the time he stresses when the apprentice goes to TAFE for a week as he needs to juggle work around to ensure that there's nothing he can't do by himself. While he understands the benefits of going to TAFE he would love his apprentices to spend more time on site. Doesn't really have much time for the TAFE teachers and their requests but will respond if he has to. Doesn't like writing reports for TAFE or site conveyancers.*
	Interests & Hobbies	*Spending time with people in his network, friends or otherwise.*
	Technology Use	*On the phone during the day to make and take calls and check emails. In the evening he uses his laptop to do quotes and invoices.*
NEEDS	**Usage Goals**	*"I need to get the most out of my apprentices while on site because they're not here all the time - time is money"*
	Emotional Goals	*"I would like to feel that my work is done in a timely and quality manner". "I hate getting into trouble because of my employers studying"*
	Motivations & Triggers	*What helps me to control things.*

Final Application Design

Design Features

The summary of design features include:

- Incorporate ubiquitous mobile technologies (such as GPS, scanner, accelerometer, gyroscope, camera, microphone, video camera etc.) found in the common mobile device
- Greater focus needed on situated and embodied learning as key pedagogy
- Potential for m-learning and other variables, e.g. gaming to invigorate engagement
- Peer to peer learning
- Functionality for mobile size with adaptation to tablet size
- Capture images / video of work completed on site. Ability to then tag, add descriptions, add audio, link to an assessment item / building compliance aspect.
- View current assessments, quizzes and some course material relevant to the assessment.
- Quick search for finding content
- Offline capability
- Push notifications
- Assessment deadlines and checklists
- Facilitator can see submitted assessment work from each student and respond accordingly.
- Captured and submitted images go to both the facilitator and employer
- Various user permissions for facilitator, employer and third Parties

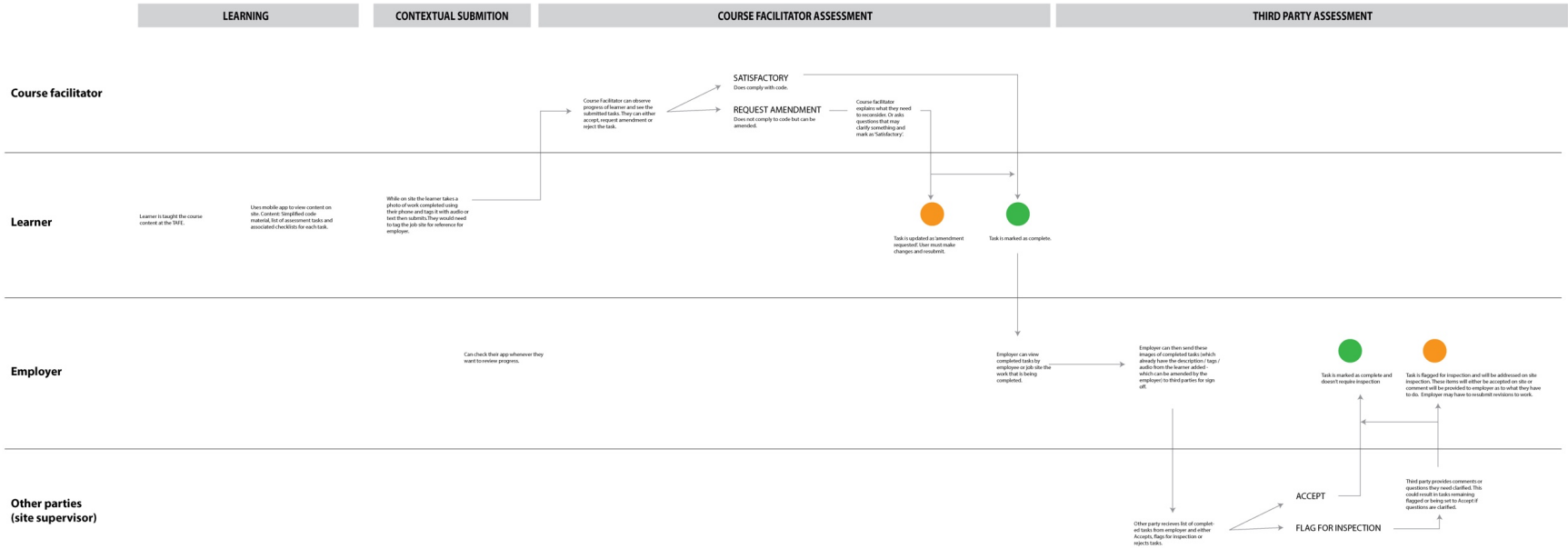
Additional Features:

- Class schedule
- All code and industry standards material accessible quickly and easily
- Employment opportunities
- Group discussion

Student Input

- Login
    - Passcode protected
    - Only login once and remember details.
    - Offline capability
    - Option to “download when connected to wi-fi for any updated course material”
- Notifications
    - Assignment deadlines
    - New assignments
    - Messages from teacher
    - Industry updates to code

Table 10: All Users Journey Map



In March 2018, design firm Loud and Clear began updating the final version of the prototype to meet their UX best practice standards to launch with users to test the wireframe versions of the prototype with recruited vocational trainers, trade apprentices, trades and builders. Loud and Clear revised the wireframes and provided a summary report of evaluation for the second suite of module development and user testing. The key insights of this work reinforced the overall themes that the Building Quality Passport is designed to address namely that building practitioners are disconnected from apprentice learning, and that apprentices are under pressure to learn skills on sites before they are covered in formal training settings. In short, they need to learn in the job in a way which can provide more obvious benefits to builders and tradespeople. The 4 key insights that focussed the final design of the Building Quality Passport user interfaces were:

1 – Apprentices are often "set-up to fail" because of a strong negative by employers who perceive them as either incompetent or not in line with construction-site work culture. There is also anecdotal evidence, particularly on domestic construction sites, that apprentices are treated as cheap labour, and are let go once qualified so companies don't have to incur higher wage costs. Thus there is a low-value placed on investing in apprentice education.

2 – Time is Money. Trade businesses are under pressure to complete projects quickly on low-margins. Removing apprentice learning from the workflow is seen as counter-productive.

3 – Tech Generation Gap: Although digital technology is being used regularly on commercial work sites, older generation tradespeople, especially in domestic construction see it as a distraction rather than a potential tool for increasing productivity and quality.

4 – Verbal Feedback Only: Due to time pressures, apprentices seldom have time for recording feedback, or self-assessing work quality systematically. They mainly receive verbal feedback from their on-site supervisors. Participants in the prototype trial indicated that they would welcome a feature where apprentices could seek advice and feedback from each other.

Final Designs:

The full designs for the final wire-frames were created in 'In-Vision' software and can be viewed at the following links:

Student – https://loudandclear.invisionapp.com/share/XKMXPI2PT4W

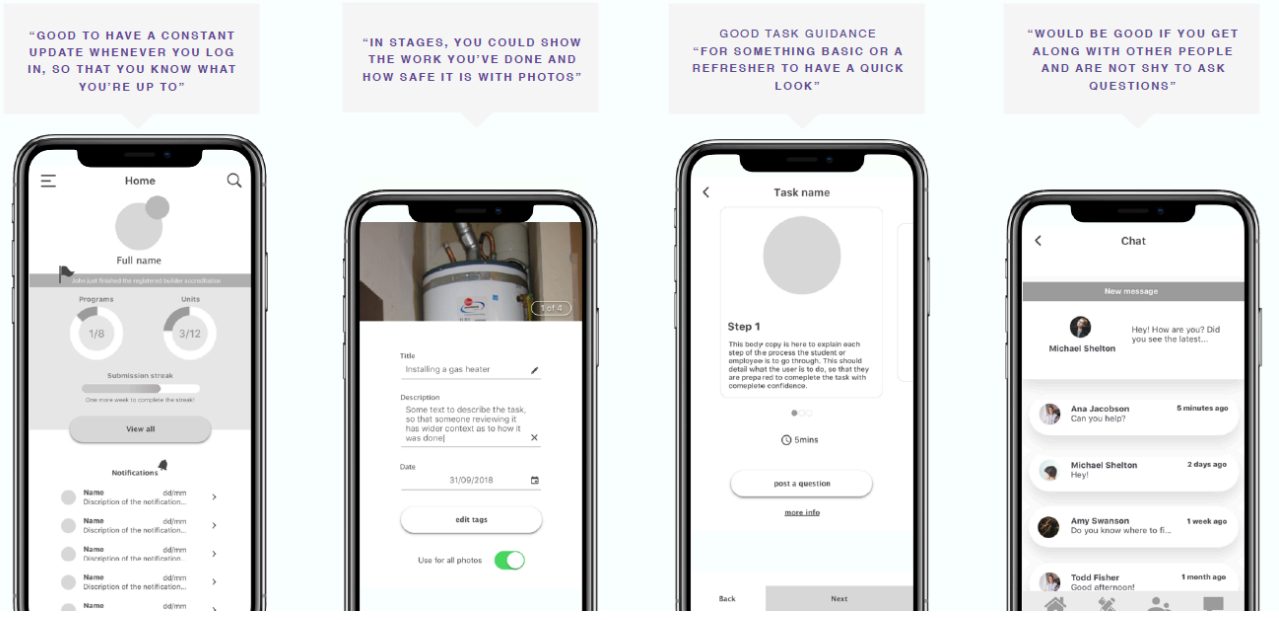
Builder – https://loudandclear.invisionapp.com/share/2RMXPIGFWZC

Surveyor – https://loudandclear.invisionapp.com/share/ENMXPHWU3GS

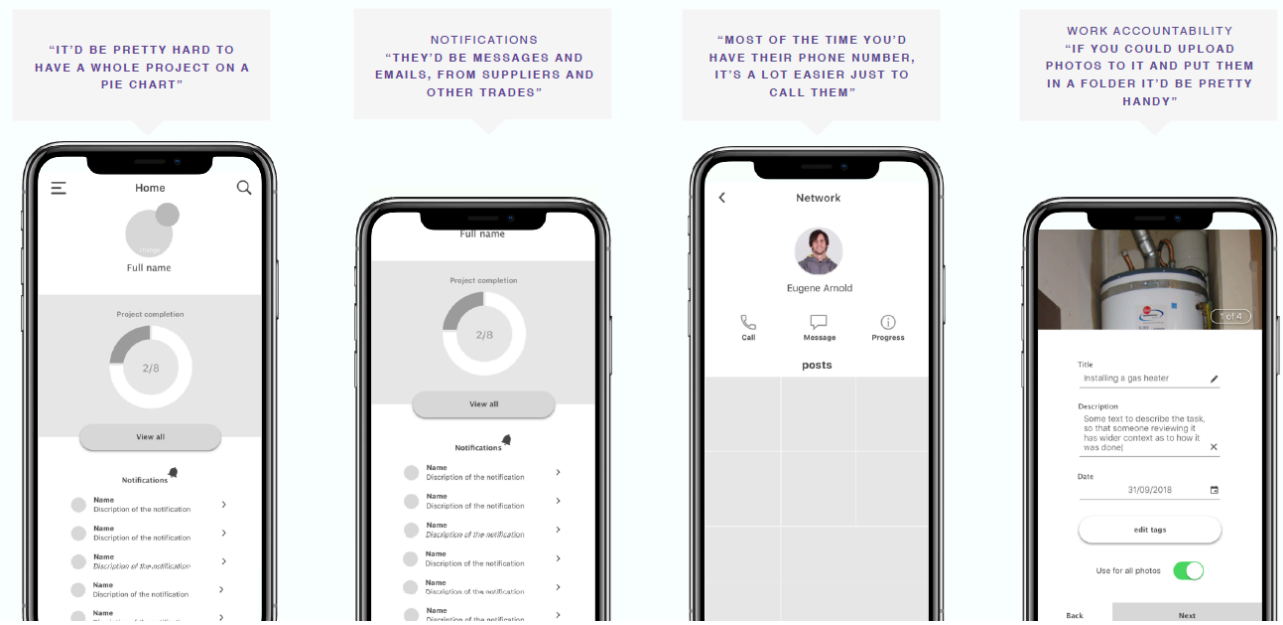
Facilitator – https://loudandclear.invisionapp.com/share/JEMXPIMSRQM

Key Features: Student View

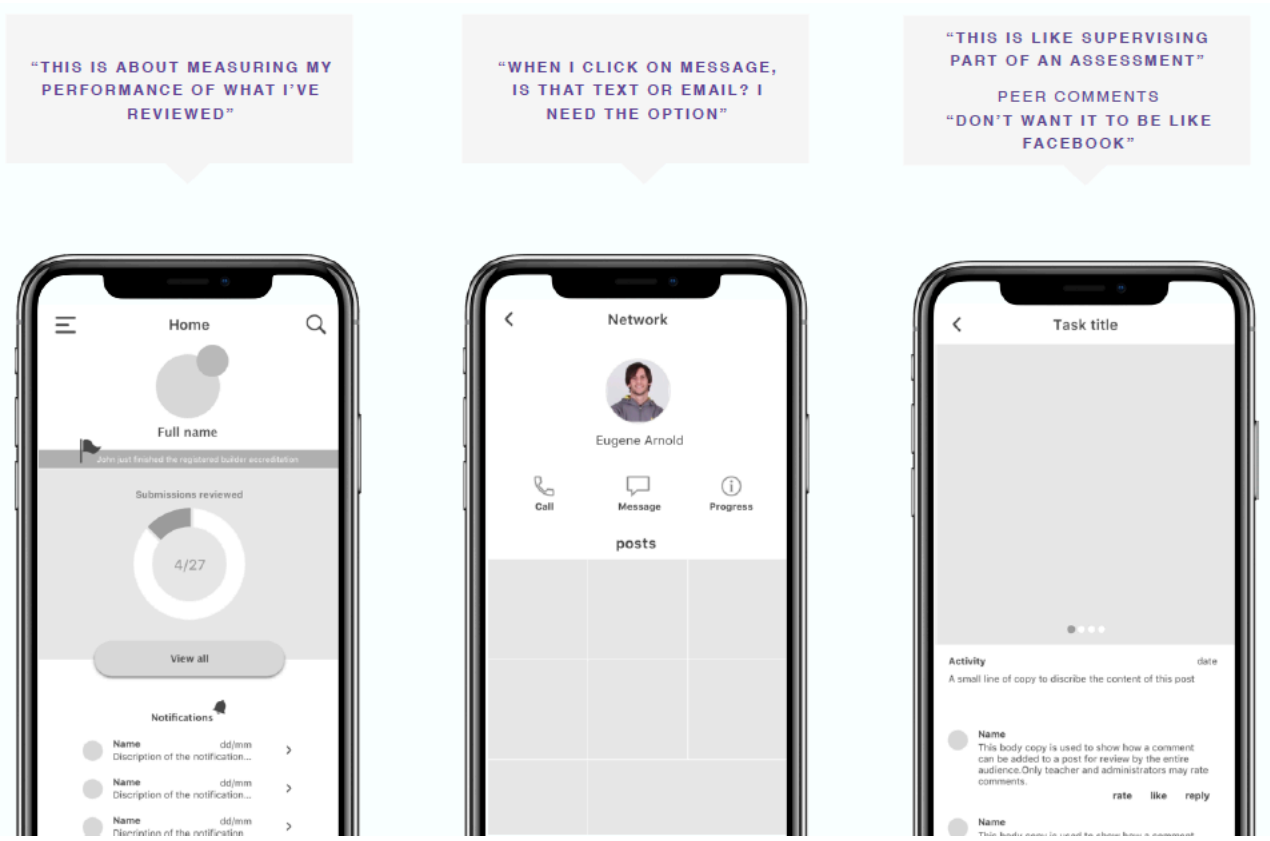
The Student View Home page is designed to provide quick feedback on learning milestones and achievements toward their qualification, as well as a dashboard displaying notifications from their peers, learning facilitator or on-site supervisors.



Key Features: Builder's View



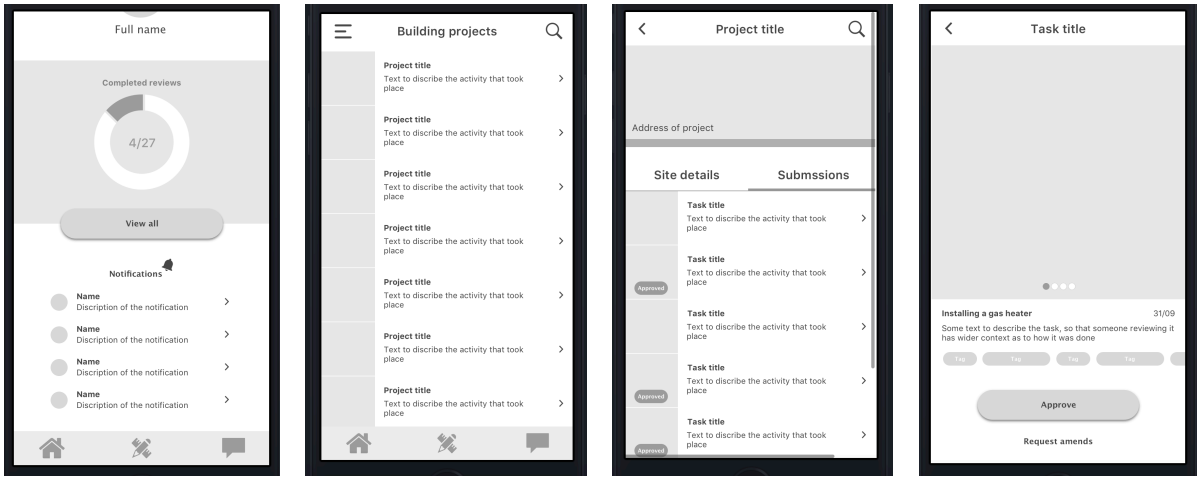
Key Features: Teaching Facilitator's View



Students and Facilitators both appreciate the potential to stream-line the assessment process using photography to demonstrate prior work on site that can be assessed.

Key Features: Surveyor View

Surveyors will be able to track the projects that they have inspected and review photographic evidence of compliant work submitted by builders that is identified by projects. This is especially important for energy efficiency features such as insulation and product energy labelling, that may be covered or obscured before a surveyor can visit the site.



Next Steps

These wireframe designs can now be further developed into a working application that can be field tested with industry partners. The project team is now exploring the feasibility of an ARC Linkage proposal to take this next step.

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Annex 1: Original Project Background and Objectives

The Research Challenge

The CRC's purpose is to provide government and industry with tools that overcome the market barriers preventing adoption of Low Carbon Living (LCL) products and services in the built environment. The research challenge addressed by this project is how to equip and motivate professionals, tradespeople and consumers to embrace LCL and work collaboratively to adopt LCL products and services.

Highly experienced and skilled professionals and tradespeople, such as architects, engineers and builders, do not promote LCL options to consumers unless they have knowledge of proven LCL solutions and the confidence to implement them. Consequently, they continue to' lock in' high carbon options, while locking out or limiting the LCL options available to other professions and trades. This interdependency highlights the urgent need for a team-based, collaborative approach to raising knowledge and motivation levels in relation to LCL solutions.

A further problem arises from the motivation and confidence of consumers to implement LCL solutions or demand that professions and trades work together to design and implement optimal LCL outcomes. Ineffective relationships between professions, trades, and consumers can result in a vicious cycle in which LCL options may not be promoted to or demanded by consumers. The original project objective was to break this cycle by equipping and motivating professionals, tradespeople and consumers to both embrace LCL and work collaboratively to design, advocate and deploy LCL solutions. The project was to trial the efficacy of team-based and game-based mobile learning (m-learning) in two related streams of research and development. The first stream was to focus on professionals and tradespeople and the second on consumers.

The Project

The project began by investigating both the emotional (what they care about) and knowledge (what they want to learn about) goals that professionals, tradespeople and consumers have in relation to built environment projects (Miller et al., 2012). This phase of the research informed the design, structure and content of the m-learning modules for both streams of research participants. Central to this work was the PhD project based at the University of Melbourne. The resulting motivational models (Miller et al., 2012) were adapted to underpin the design of the mobile learning (m-learning) modules. A key goal was to enable participants to work more effectively within the cross-functional teams typically found in built environment projects. The first module was to be trialled with a cross-functional team (likely to be sourced through BuildSmart Australasia) and the associated PhD student would work closely with the industry partner(s).

Research participants for the second stream were to be teams of people who work within the same organization, (likely to be sourced through the Master Builders Association Victoria). In order to increase motivation to participate, a game-based element was to be included so that teams competed with one another as they progress through the module. Module content was to focus on increasing knowledge of the total carbon footprint of buildings and of LCL solutions for both houses and workplaces. Simple, practical LCL solutions that consumers could deploy themselves was to also feature. A key goal was to equip and motivate participants to become confident, well-informed 'expert' consumers who drive demand for LCL products and services. Research sites and participants for both research streams were to be sought from or through the CRC partners and the associated PhD students were to work closely with partners.

Collaboration between the research participants was to be enabled by the use of interactive m-learning modules, which could be accessible from the smart phones or tablets used by participants. M-learning was chosen for a number of reasons; including the personalisation, flexibility and scale of delivery enabled by mobile devices, and that Australia has the world's second-highest rate of smart phone uptake in the world (ACMA, 2013). Smart phones have become essential tools for professionals and tradespeople, as part of the so-called 'mobile office', and their use is likely to increase in future.

To ensure the currency and relevance of the m-learning modules, the project team worked closely with the CRC's industry partners in all project phases, including the design, development and delivery of the modules. Module content was to be informed by the findings of the *Education and Training Scoping Study* (Winfree et. al, 2013). Knowledge transfer between the projects is ensured by a cross-over of personnel and by co- location in the Swinburne Centre for Urban Transitions (formerly Swinburne Institute for Social Research).

The *Education and Training Scoping Study* (Winfree et. al, 2013) also found support from industry partners for the use of m-learning due to the limitations of place and time-based learning, such as seminars, that they had experienced. This finding was supported by discussions with the industry partners associated with this project.

Research Questions

Stream One

1. How can team-based m-learning be used most effectively to increase the knowledge and motivation of professionals and tradespeople to implement LCL solutions in the built environment?

2. How can team-based m-learning be used most effectively to increase the capability of professionals and tradespeople to work collaboratively to maximise LCL outcomes in the built environment?

Target Audience may include: planners, designers, builders, design/build firm, trades people, energy experts, engineers, owner or developer, financial analysts, quantity surveyors or local government staff

Stream Two

1. How can team-based m-learning be used most effectively to increase the knowledge and motivation of consumers to implement LCL solutions in the built environment?

2. How can team-based m-learning be used most effectively to increase the capability of consumers to work collaboratively with professionals and tradespeople to maximise LCL outcomes in the built environment?

Target Audience may include real estate agency, property services agency, retail store, local government agency, education institution

In seeking to answer these questions, the project team was to trial different approaches to team design and trial simple gaming elements as a means of increasing motivation and engagement.