Designing for learning in The Cube

Research findings

Executive Summary

This document reports findings of the project *Designing for learning in The Cube*, conducted 2018-2020 at QUT. Data was gathered in two stages – a survey and interviews[1].

The Cube is currently only used in QUT teaching in limited ways, primarily as a poster presentation device. It is used more as an outreach programme to schools.

The study participants identified the following benefits of integrating The Cube into Higher Education curricula:

- Visualisation
- Experimentation
- Motivation
- Collaboration
- Adaptability

The participants identified the following potential strategies for integrating The Cube into Higher Education curricula:

- Community hub
- Resource centre
- Showcase
- Link to other organisations
- Crowd sourcing
- Templates and wizards
- Research tool
- Instructional tool
- Social space

Hurdles academics raised, influencing their ability to use The Cube in their teaching:

- Lack of knowledge about its availability and the process for using it
- Lack of creative ability
- Lack of finances
- Lack of time

Pragmatic considerations are identified when incorporating The Cube into university teaching and an example activity given. Some theoretical foundations are outlined.

[1] With QUT Ethics Clearance, UHREC Reference number: 1700001143

A best practice guide has been developed, drawing on these findings, for use by QUT academics and the Cube development team.

TABLE OF CONTENTS

1. CUBE INTEGRATION INTO QUT CURRICULA 6

2. CURRENT USES 6

3. THE BENEFITS 6

3.1. VISUALISATION 6
3.2. EXPERIMENTATION 6
3.3. EXPLORATION 7
3.4. MOTIVATION 7
3.5. COLLABORATION 8
3.6. ADAPTABILITY 8

4. ADDITIONAL STRATEGIES 8

4.1. COMMUNITY HUB 8
4.2. RESOURCE CENTRE 9
4.3. SHOWCASE 9
4.4. LINK TO OTHER ORGANISATIONS 9
4.5. CROWD SOURCING 10
4.6. TEMPLATES AND WIZARDS 10
4.7. RESEARCH TOOL 10
4.8. INSTRUCTIONAL TOOL 10
4.9. SOCIAL SPACE 11

5. BEST PRACTICE 11

5.1. ACADEMICS' CONCERNS 13
UNSURE OF ITS AVAILABILITY AND THE PROCESS 13
LACK OF CREATIVE ABILITY 13
LACK OF MONEY 13
LACK OF TIME 14
5.2. CUBE DEVELOPMENT TEAM CONCERNS 14
PROTECTING THE SYSTEM 14
PROVIDING GUIDANCE 14
5.3. COMMENTS 14
NOT A SILVER BULLET 14
PRAGMATICS OF CUBE TIME 15
SUPPORT AVAILABLE 15
DEVELOPMENT TIMELINE 15
5.4. AN EXAMPLE ACTIVITY 16

6. THEORETICAL FOUNDATIONS 17

7. ACKNOWLEDGEMENTS 19

8. APPENDICES 19

8.1. DATA COLLECTION INSTRUMENTS 19
SURVEY (5 MINUTES) 19
FOCUS GROUP QUESTIONS – ACADEMICS AND PROFESSIONAL STAFF 19
INTERVIEW QUESTIONS - ACADEMICS AND PROFESSIONAL STAFF (BASED ON FOCUS GROUP RESPONSES) 19
FOCUS GROUP QUESTIONS – ACADEMICS AND PROFESSIONAL STAFF (NOT USING THE CUBE) 19
FOCUS GROUP QUESTIONS – STUDENTS 20
8.2. PARTICIPANTS 20
SURVEY 20
INTERVIEWS 21

This document reports findings of the project *Designing for learning in The Cube*, conducted by Ian Stoodley and Briony Wainman, with guidance from Simon Harrison, 2018-2020 at QUT.

Methodology

The project adopted a two-stage data gathering process (details in appendix):

- A university-wide online survey to determine those interested in using The Cube in their teaching.
- Interviews with consenting survey participants about using The Cube in their teaching.

Those interviewed in the second stage included:

- Academics who had used The Cube or would like to use The Cube in their teaching
- The high school Cube program coordinator
- The Cube manager

The survey responses were integrated into a spreadsheet and synthesised. The interviews were transcribed and examined for thematic analysis. The goal was to represent the range of experiences.

Structure of this report

These findings are reported here following the project objectives:

1. Explore the ways The Cube is integrated into QUT higher education curriculum.
2. Create a profile of the current uses of The Cube.
3. Identify the benefits of integrating The Cube into higher education curriculum.
4. Identify additional uses and strategies that integrate The Cube in higher education curriculum.
5. Create a best practice guide for integrating The Cube in higher education teaching and learning.
6. Explore, elaborate on the theoretical foundations for using The Cube in higher education curricula.

Additional useful comments which don't fit into the original objectives are in final sections:

7. Academics' concerns.
8. Cube development team concerns.
9. Comments.

An example of a comprehensive learning activity emerged in the interviews:

10. An example activity.

1. Cube Integration into QUT Curricula

The only way The Cube is currently integrated into QUT curricula is as a link to assessment. Students present posters of their work on The Cube and that poster is marked. Incidentally, fellow students get to see how their cohort has approached the assessment.

2. Current uses

The only current use of The Cube in QUT curricula is as a poster presentation device.

There is also an active program outreaching to schools. It includes workshops, events and teacher professional development. QUT STEM Ambassadors interact with school students during their visits.

The vision of The Cube developers was to embrace community, high school, undergraduate and post-doctoral engagement.

3. The benefits

The benefits of integrating The Cube into Higher Education curricula, as identified by the study participants, are grouped under:

- Visualisation
- Experimentation
- Motivation
- Collaboration
- Adaptability

3.1. Visualisation

The Cube provides the opportunity for content to be presented in a visual manner. This helps concrete learners, who do not process ideas in abstractions. An example is an aerodynamic model which shows the way air flows over various objects, enabling the student to see airflow and conceptualise the forces at work.

> The benefit… is they are testing an hypothesis on The Cube and… they can actually visualise it. Those students who are not so abstract in their thinking can actually see for example the wind flows across one of the wings. We have some 3D printed aerofoils that they use in the workshop and they use those on The Cube wind simulator. (I5)

3.2. Experimentation

The Cube provides an environment where it is safe to experiment and learn through risk-taking. This caters to the needs of kinaesthetic learners, who learn by being bodily engaged with the new material. A student may push a virtual system to breaking point, without fear, loss of life or undue expense. An example is making fuel mixes for rockets which optimise endurance in relation to performance.

> This technology is able to do simulations that are realistic enough for people to engage with the technology knowing that it's technology but also knowing that it's safe, to put your hand to pat a shark as it goes past you and have the shark turn around and you can have a look at its teeth. (I1)
>
> The kinaesthetic learners are in their happy place. They can really easily change the mix and see the effect, change the mix see the effect... we want them to be risk takers. Something like that, they know they can go in, they can interact, they can take a risk, change the mix, oh, the rocket explodes, I'll try something else. (I5)

3.3. Exploration

The Cube supports learning by allowing easy access to additional information on topics students are interested in or don't understand. It can provide a degree of detail not previously available to the learner. For example, if they come across a concept they aren't familiar with, they can select it and layers of additional information are immediately available.

> you can always understand what the person has an interest in and expand that if they want to follow it through… it's an extension… touch the button and all of a sudden it explains what it means and what it may be used for, its history… the ability to take an artefact and expand it in the dimensions that the media producers can think of to take you in. That's the strength, the interest side and the ability for individuals to follow their own little path through from the beginning to the end. (I1)
>
> I had one girl come to my office. She said "I feel so stupid but I hear the tutor say things like annotations, checklist, observations… and I don't know what any of it is." If you could touch on it and it'd have an example of each element. (I6)

3.4. Motivation

The Cube attracts the attention of students, due to its unique design and technological functions. It is also fun and easy to manipulate and view. This means students may interact with it without realising they are learning in the process. In addition, The Cube can provide the opportunity for students to approach a topic from a different perspective to that taken in the classroom or textbook. An example is incorporating a Cube experience in the midst of a longer workshop, whereby the participants perceive they are having a break when they are actually still engaged with the topic. It is also interesting for the teaching team to use The Cube, they find it stimulating.

> The students love it. They take photos of themselves there, when the posters turn on, there's the big 'Wow!' factor… It's a different assessment piece for them, it's something they haven't had to do at all. So, it is a unique assessment piece. It certainly gets them engaged in the assessment. They enjoy it. (I4)
>
> It's a nice way to give a break instead of teachers or students sitting down… get up and have a break but they are still learning, engaging, doing something active. (I5)
>
> A big one is that it is something that is novel to the students. A lot of my students come in thinking interactive design is screens and phones. So, it's really nice to give them a challenge of something they've never designed for or thought about designing for. (I7)

3.5. Collaboration

The Cube provides a working situation where students learn from each other by seeing each other's solutions to problems. The space caters for collaborative ventures which engender teamwork. An example is a team working to code virtual robots to recycle rubbish faster than another team.

> it's available to lots of people at the same time. It's not just a one-on-one thing. It's collaborative and community oriented. (I1)

> just the right number of people can stand around and talk and see each others', it's perfect for that use (I3)

3.6. Adaptability

The Cube provides for dynamic interactions, allowing individuals to approach the content according to their preferred learning styles and interests. A student can explore to the depth appropriate to their level of ability. An example is a student may choose to learn about gravity by experimenting with the way objects interact under differing gravitational pulls or by choosing information panels to read about gravity theory.

> The Cube provides that capability to dynamically adjust. To say, what interest does a preschool person have in The Great Barrier Reef as opposed to what a Year 12 or even a graduate student have an interest in those things (I1)

4. Additional strategies

The additional strategies for integrating The Cube into Higher Education curricula, as identified by the study participants, are grouped under:

- Community hub
- Resource centre
- Showcase
- Link to other organisations
- Crowd sourcing
- Templates and wizards
- Research tool
- Instructional tool
- Social space

4.1. Community hub

The Cube may provide a centralised space for activity which draws on citizen science projects. The data from these projects may be useful for students in their studies. An example is collecting and displaying evidence of koala presence, drawing on reports from the wider community of koala sightings, including a photograph and GPS location.

> something like The Cube lends itself to community growth. Like a community scientist, you can have lots of people contribute to it, if you set it up in the right way

> to be open to the community, rather than it being a device that shows something, if you leave it open it is in a sense organic, it can grow. (I1)
>
> If we want to influence the community, then we have to be part of that community in some way, our community has to be part of us and it has to be part of the broader role. So, if we're going to use this as a medium to do that, then that's a strength. (I1)

4.2. Resource centre

The Cube could act as a resource centre, presenting core topics for use by many others. Individual academics who don't have the capacity or ability to develop conceptual modules could draw on this resource as they present their units and as academics had ideas for new topics, a central development team could assist them to produce a new module.

> It's a very expensive thing to gamify all of our learning materials. So, if some of the big concepts are done by The Cube, the rest of us don't have to waste resources on making that… (I1)
>
> I'm happy to supply the science end of it and we can supply a lot of the pictures… we need somebody to put it in, make it touchy and feely. (I2)
>
> I don't know how you'd do it. You'd have to work with one or two really high quality people and showcase some of the great teaching activities that they've come up with. (I6)

4.3. Showcase

The Cube may be used to showcase to the wider community the good work QUT students are doing and the good contributions they will be making in the future. An additional benefit of this is their cohort can learn from what they see displayed. As others see students' work, they are encouraged to be involved and apply the outcomes.

> Some of them have done really good jobs and I've thought it'd be nice to showcase them. So, I've been thinking more as a showcase for student work. (I6)
>
> I was thinking wouldn't it be great to showcase… some of the really good examples and to advertise to the wider community how great our pre-service teachers are. And let the ones coming through see what's required. (I6)
>
> some of the students' work was amazing… the library invited three of my best students to present their work to the team. And the team took ideas away which got incorporated in what they do (I7)

4.4. Link to other organisations

The Cube may serve as a link to neighbouring organisations and open connections with them. Museums may extend their displays into The Cube space. The different locations could direct visitors to each other. An example is a study of corrosion could be linked to the Maritime Museum across the river, The Cube display providing a representation of the ion interactions happening in different types of corrosion seen on vessels in the museum.

> because The Maritime Museum and here are so close… it seems funny that we're not channelling them through here if only for an instant. It's a ten minute walk

> across the bridge, they could have lunch somewhere here and walk through The Cube. (I2)
>
> it gets people from outside interested in the subject, so it creates new connections even outside the uni… it has this cascading effect… because they are engaging with something meaningful it opens up new pathways to other things outside. (I7)

4.5. Crowd sourcing

The Cube may be augmented by students developing an additional section for an existing wall display. An example is students creating a new fish species for The Reef.

> One of the ideas was to have a new reef but a dead one... Then we spend a period of time after that, one or two years, adding new parts to it… regrowing it. You add fish, you add corals. And we'd get it back to what it is now, but using new technology… engaging students to create some of the animation… create a fish, animate it, and you can put it in The Reef. And you'd have to come to The Cube to see it… that way we can almost crowd source and fund a new reef. (I3)

4.6. Templates and wizards

The Cube may have various templates and wizards that make using it straightforward. These could cover booking the space, creating posters and organising events.

> Part of the plan was to have this event wizard, this device or website that could be done not by us but by someone else. They would set all the posters up themselves, then send that, when it's done, to us and we'd check it. (I3)

4.7. Research tool

The Cube could supply user interaction data which is useful for research projects. This may be to do with technological interactions, or on another topic for which a Wall display is developed.

> There was a car simulator at one stage that they were advertising they were using it as real research about driving behaviours – that was a double whammy for me, I get to play a car driving game as well as contribute to research… Then if you reverse that and look at where people have been and how they get there, you can reengineer those styles. It's the idea of mining the information. (I1)
>
> They might do this in their labs but they never probably understand what's happening on the atomic scale. So they can get in a little bit closer. (I2)

4.8. Instructional tool

The Cube could be designed to exploit its strengths as a support to teaching goals. That design may cater to various learning styles and allow learners to approach a topic following many different pathways. It may allow teachers to pursue learning objectives more effectively than using traditional methods. It may provide an engaging environment where students desire to be.

> That's the strength, the interest side and the ability for individuals to follow their own little path through from the beginning to the end… Some people learn in a very

> visual sense and they might want to see lots of things, and some people want to learn in a very ordered, structured way… people construct their own internal knowledge in different ways. They may end up at the same place, but how they get there, they have different journeys. So thinking about that individual catering is one strength. (I1)
>
> when they go into a conference, they can see how they would interact and that it's not only a presentation of your poster but you're standing there and talking about it as people walk around. So, it's trying to introduce them to that as well. (I4)
>
> You could always make up virtual patients. You can ask this and these are their responses. (I4)
>
> I could imagine a story board with some of the artefacts of what teachers are using. Like the great ways they might do assessment and how they might do some of their really innovative teaching… something animated or a video... Then talking about the way you could do assessment to find out something. We talked about universal design of assessment, so inclusive assessment practices. A hypothetical example of what a kid can do. Some data the teacher might have collected. Then some learning experiences they may have done. (I6)
>
> If they don't know what a checklist is, they could just click and there'd be some examples. (I6)

4.9. Social space

The Cube may provide a space for students to meet socially, and in at the same time encourage them in their studies. Social interaction is understood to be the reason many students travel onto campus, rather than study. Meeting their felt need can provide an opportunity to encourage them to also meet their study needs.

> If you talk to students about why they are on campus, they're not here to learn, they're here to have social interaction. So, if that social interaction directs them in some way to The Cube, where they are encouraged to do something at The Cube then we can combine that social aspect of them coming to campus with the real reason they should be here being to learn something, without them necessarily knowing it (I1)

5. Best practice

A best practice guide has been developed, for use by QUT academics and the Cube development team.

Items for inclusion in the guide are:

- What can be included on The Cube?
  You may present material for a single class (e.g., student posters), through to a public display (e.g., an experimental environment). However, the more public your presentation is, the greater the amount of preparation needed.

Also, content that is already displayed may be useful to you (e.g., concerning Reef biodiversity). Existing content is listed on the QUT website (http://www.thecube.qut.edu.au/cube-screens/all.php).

- Who do I contact to talk about my idea?
  The contact person is Simon Harrison simon.harrison@qut.edu.au

- How do I arrange Cube display time?
  Follow this link:
  https://qutvirtual4.qut.edu.au/group/staff/engagement/events/booking-a-space-or-venue/qut-precincts-managed-spaces
  See the instructions under *Self-Managed Venues - function and engagement spaces*
  See *The Cube specific information page*, where there are content guides and a request form.

- What constraints are there?
  Your presentation may need to fit in with other events in The Cube space.
  If your presentation is for public display, the general public must be able to understand it and find it interesting, at least at first encounter.

- Is there any help available?
  The Cube development team can help, depending on their other commitments.
  See *Content development and templates for events* for templates, with formatting instructions:
  https://qutvirtual4.qut.edu.au/group/staff/engagement/events/booking-a-space-or-venue/qut-precincts-managed-spaces/the-cube

- What advantages of including a Cube activity have others found?
  - The Cube is a stimulating space, so students are generally excited to participate in activities there.
  - The large size of the Cube display makes visualisations life-like and easily viewed.
  - The Cube format engenders group work, with small groups able to collaborate on a common project and students able to see each other's work.
  - Clever design encourages learning through experimentation and provides a safe place for students to take (virtual) risks. It can also accommodate different learning styles, and so cater to individuals' preferences.
  - An activity may integrate experiences in other spaces, for example the Queensland Museum, engendering linked activities and connections with the wider world.

The best practice guide draws on educational theory as well as participants' concerns and observations.

5.1. Academics' concerns

These concerns are the hurdles academics raised influencing their ability to use The Cube in their teaching.

Unsure of its availability and the process

Academics were uninformed about the availability of The Cube for their use. One thought it was for science-related content only. Another thought it was too busy to get access to it. Another felt many internal approvals were required to make it possible. One academic was concerned that Cube Calendar bookings were not confirmed until late in the semester, making them uncertain the activity would actually happen.

> I actually have no idea at all… how to use The Cube or how to get access to it, what is the process about it. (I1)
>
> I have not been aware that it's a resource that we can use in that way. I thought it was all preordained that someone would think of a theme. (I1)
>
> it seemed quite a hard process, there seemed to be quite a few approvals for me to use it in our unit. (I4)
>
> You can't book it too far in advance… it never seems to be guaranteed, which is difficult because if I don't have that assessment piece, I have to come up with something else. (I4)
>
> someone said The Cube is so busy, you'd never get on (I6)

Lack of creative ability

Academics feel ill equipped to produce material of acceptable standard for The Cube and to integrate the material into their learning design. They need access to learning and interactive designers who can develop their content and tentative presentation ideas into a viable product.

> I'm not creative enough either, so it's not just getting access to the technology it's also getting access to all those other professionals who can put that together to make it a realistic learning environment. (I1)
>
> That's a bit too techy for me, to write it up. The students are pretty switched on in that sense but I don't know how I'd go about writing it up, to set the assessment piece up. (I4)

Lack of money

Academics felt under resourced to develop a learning activity of this scale. Any educational use of The Cube beyond simple poster sessions would need funding for project management, design and development. They also needed help integrating the activity into their unit plan.

> It came down to cost in the end and the cost was quite high unless we could get some proposal in to QUT to get it over the line. (I2)
>
> if I was given $250,000 specifically for my course, now you're talking. Then I can employ a research assistant, I can engage with the computing people about what simulations are possible (I1)

> That's a bit too techy for me, to write it up. The students are pretty switched on in that sense but I don't know how I'd go about writing it up, to set the assessment piece up. (I4)

Lack of time

Academics feel time poor. Funding for the development of a large learning activity would ideally include pay-out from their normal teaching responsibilities.

> I walk past to see what's there and think it's been well designed, well thought out and put up. And if you think "I'd like to do something about that… but it'd have to be after I finish lectures, next year…" and next year you think the same thing. (I1)

> The overheads associated with delivering a course now are so horrendous that when you say to do something like this, it would absolutely have to be in your spare time which doesn't exist during the semester… Until there is no other distraction, I'm unlikely to do it. (I1)

5.2. Cube development team concerns

The Cube development team raised concerns from their side and were working on solutions.

Protecting the system

The development team is responsible to ensure the existing displays are not disrupted by inexperienced developers. A response to this is to have a safe development area.

> We're a little bit protective of it at the moment, and for a good reason that we can't let anyone get onto it because with a slip of the hand you can stop everything working and it can take weeks to put it back again. If we create this fenced garden, where people can experiment on it, then I think that might be really exciting. (I3)

Providing guidance

The team could provide guidance to help developers.

> The Cube team are designing a framework or some examples to give to people to say this is the project, this is how we got the thing working, and if you want a pretty swirling background with text floating around this is the one to use or if you want video this is the one to use… they'll be able to plug these templates in and they'll be able to just press a button and it'll show… (I3)

5.3. Comments

Various useful comments concerning the constraints of using The Cube were also made.

- Not a silver bullet
- Pragmatics of Cube time
- Support available
- Development timeline

Not a silver bullet

While a Cube experience in the curriculum may provide an interesting diversion and attraction to students, it will not meet all the teaching needs in a unit. It needs to be seen as an instructional element, amongst others. The interaction with The Cube needs to be

planned so it aligns with the unit's objectives. Careful timing of the interaction in the semester and within a longer class session will help maximise its effectiveness. For example, a unit on chemistry may lead the students to propose specific chemical interactions, which may then be tested in The Cube when firing rockets, and then written into an assessed report.

Some consideration needs to be made to what The Cube adds to existing classroom and personal technologies. The size of the display is one advantage, which assists visualisation and engenders group work. On the other hand, The Cube display is not necessarily high definition so not appropriate to present fine detail.

Pragmatics of Cube time

The location of The Cube creates a challenge for students whose home campus is elsewhere. Travel time from and to adjacently timetabled classes may be much greater than usual. Disruption to the participants' days may be significant. The additional demands on both the teaching staff and the students need to be justified.

In addition, given other demands on The Cube, the class may need to be scheduled for a time of day other than its place in the usual timetable. If school programs are running, sometimes only late afternoon or early evening times may be available.

Also, only a clearly defined timeslot may be available for your display. Thus, the activity at The Cube may need to continue in a different format at another time.

Communicating with a group in The Cube physical environment may become challenging, given the size of the space and that excited participants may be quite noisy. This can limit the amount of verbal instruction that is possible.

Support available

Academics are already stretched to meet their responsibilities. To take on the development of a new instructional tool, they feel the need for help with time, finances, justifications and creative inspiration. Some assistance is possible from The Cube development team. However, they are also under their own pressures. The development team can provide technical assistance, however are dependent on academics for ideas and factual content.

The Cube is a public space whose main audiences are the general public and high schools. A project that caters to those audiences as well as university students can attract more formal Cube support and enable its display in normal visiting hours.

Academics are not aware they can have content on The Cube, so an advertising strategy is needed to attract proposals.

Development timeline

The time it takes to develop a project for display on The Cube varies with the kind of project.

A poster display may be prepared within a week, if the materials sent for display are in good order.

A significant wall-sized project requires a year.

5.4. An example activity

One academic had reasonably advanced ideas for a possible activity involving the Maritime Museum[2], a professional association and The Cube.

> I work closely with an industry association… and they have expressed an interest, like they sent me an email today, of trying to facilitate interaction between The Cube and The Maritime Museum across the river.
>
> Try to teach people about materials and the degradation of materials… There are a million things we could do, but what would aesthetically be the best I don't really know. We're planning on setting up a display at The Maritime Museum and because The Maritime Museum and here are so close… they get a huge number of students into The Maritime Museum… school kids…
>
> We're going to put a bit of a display over there. They just walk around the ships… we'll put a display of things that have failed but if they could do an interactive thing here of materials, or of failure of materials, that would work. It's an offering, if they wanted to come here they would only sign one consent form to do the trip – come here for the morning, go there for the afternoon…
>
> A very simple example would be taking a polymer and being able to show how flexible it is, so being able to move it up and down. Then turning on the sunlight and irradiate it a little while, then moving it and having it break... having a brittle fracture showing. You might even be able to show how much pressure I put on it and it shows a graph of the pressure, then as you get to the yield point, and then it breaks… something along those lines. Or you could put something in acid and watch the ions come out of it, and show what is actually happening. You have a piece of metal and when you put it under the microscope it's actually just a whole lot of ion atoms stuck together. You could show the electrons coming out of the metal and the atoms turning into ions and dissolving in the acid… you could make like a little movie and you could do the same with aluminium… You could have three or four different… almost like a virtual lab but where you can see on the atomic scale what's going on. So you could put aluminium into a different solution and see that it actually forms an oxide film and doesn't corrode at all. Or you could put steel in concrete and show that steel doesn't corrode in concrete but aluminium does.
>
> They might do this in their labs but they never probably understand what's happening on the atomic scale. So they can get in a little bit closer. And you can have it decorated with pictures, electron microscope pictures… and there's eight different types of corrosion, so you could investigate each one… If we were doing it with The Maritime Museum we could have a ship, we're doing some stuff on asset management so this might be nice, spot the corrosion, then grab a hold of the

[2] The Maritime Museum has since closed, however this still provides an example of a collaborative project.

corrosion, have a look at it, play around forensically to try to figure out what has happened

I'm happy to supply the science end of it and we can supply a lot of the pictures… we need somebody to… make it touchy and feely. I can get some funding… it would need to be cobranded…

I've got a course that runs next semester on materials failure… It'd be simple, I'd send them over there and design some assessment around it, and away you go! At the moment I get them to walk around here and find things that are falling apart… (I2)

6. Theoretical foundations

Constructivism has usefully been applied to higher education and provides insights into learning in the context of The Cube.

Alt[3] outlines constructivist principles (p377):

- constructive activity – *learning to learn*, active meaning making, student-generated; *real world orientation*, personally interesting, direct relevance to the learner; *multiple perspectives*, students approach content from multiple points of view, enhances understanding and adaptability; *in-depth learning*, learners draw on existing knowledge to seek clearer understanding, learners creatively apply learning to their future
- teacher-student interaction – *teacher as facilitator*, the teacher is not the sole authority, students provided environment for self-regulated learning
- social activity – *learning is influenced by social factors*, communities of enquiry and dialogue are integral to learning, verbalisation of formative ideas helps refine and reinforce them

When reflecting on constructivism, Ambrose et al.[4] propose seven research-based principles for smart teaching in higher education. The design of learning experiences in The Cube can be helpfully guided by these principles to enhance learning.

1. **Prior knowledge** – Students' prior knowledge can help or hinder learning. Ideally, students build on a foundation of robust and accurate prior knowledge... if students' prior knowledge is insufficient for a task or learning situation, it may fail to support new knowledge... if it is inappropriate for the context or inaccurate, it may actively distort or impede new learning. To help students learn, it is important for instructors to (a) clearly explain the conditions and contexts of applicability, (b) teach abstract principles but also provide multiple examples and contexts, (c) point out differences, as well as similarities, when employing analogies, and (d) deliberately activate relevant prior knowledge to strengthen appropriate associations. The dynamic and interactive nature of The Cube can help rapidly situate students to the

[3] Alt, D. (2016). Contemporary constructivist practices in higher education settings and academic motivational factors. *Australian Journal of Adult Learning, 56*(3), 374-399.

[4] Ambrose, S., Bridges, M., Lovett, M., DiPietro, M., & Norman, M. (2010) *How learning works: 7 research-based principles for smart teaching*. San Francisco, CA: Jossey Bass. https://firstliteracy.org/wp-content/uploads/2015/07/How-Learning-Works.pdf

context, review general principles and provide practical examples, and thus enable them to draw on useful prior knowledge as they focus on the specifics that interest them. For example, The Reef provides a visual orientation to the environment being represented which presents the various elements of the environment and their interactions. Information bubbles provide more detailed information about the elements the students select.

2. **Knowledge Organisation** – Learning content may be organised to allow students to see connections between the different elements of what they are trying to learn, like timelines and graphs, but the interactive element means that you can also manipulate the information to compare elements or perceive change. The Cube enables engaging and logical design which organises learning material in a beneficial way. The Cube can also potentially be programmed to learn from interactions with its interface, to track how a student organises their existing knowledge and to detect gaps in that knowledge.
3. **Motivation** – Students are likely to be motivated to learn when they encounter a learning activity they value, expect to succeed and encounter a supportive environment. The Cube can be thus designed to motivate students to learn. Students who are intrinsically motivated to learn using this tool will persist in independent learning to achieve their goals.
4. **Mastery** – Mastery depends on students acquiring component skills, integrating them, and knowing when to apply what they have learned. The Cube can help students to understand and construct complex concepts from component parts, for example choosing rocket fuel mixes and seeing the consequences of their choices when they launch the rocket. Students can practice these choices by experimentally repeating and adjusting them until they achieve a successful launch. They can then experience the satisfaction of multiple successful launches as they apply the lessons they have learned.
5. **Goal-directed practice** – Practice needs to be focused, accompanied by feedback appropriate to the student's skill level and frequent. The Cube can enable such practice. For example, in the robot activity students receive immediate feedback, whether the robot does what they had intended, which is timely.
6. **Appropriate social, emotional and intellectual environment** – Students are whole, complex people and a positive climate enables them to develop a full range of social, emotional and intellectual skills. The Cube can be used as a tool to engender such an environment, where students are able to engage at a level appropriate to their existing level of maturity. In the robot example, people with limited understanding of coding can get the robot to move quite easily; people with basic coding can use the modular drag and drop coding to program the robots to perform particular actions; people with advanced coding knowledge can compete with another team to make the most efficient program for achieving shared goals.
7. **Self-regulated learning** – Learners are introduced to a suite of approaches to self-monitor, reflect, strategize and adapt their approach to learning. They thus equip themselves to be more effective learners. In the pirate exercise, students learn how to manipulate the device to change the angle and force necessary to hit another pirate ship with their cannons. To achieve that, they need to work out what the goal of the game is, they need to evaluate their existing knowledge of these maths concepts, then they need to devise a plan and monitor their progress as

they aim their cannons. These concepts are associated with the creation and maintenance of self-regulated learning because the students are responsible for devising their actions at each stage.

While The Cube has potential to contribute positively to students' learning, activities on it need to be intentionally designed in the light of the above principles in order to maximise its usefulness as a learning tool.

7. Acknowledgements

This project was funded equally by QUT Precincts and proceeds of QUT Science and Engineering Faculty Master of Information Science course professional development seminars.

8. Appendices

8.1. Data collection instruments

Survey (5 minutes)

1) Name
2) School
3) Faculty
4) HERN member
5) Full time or sessional academic
6) Are you involved with using The Cube for teaching?
7) What is the unit code(s) and name(s)?
8) How is The Cube being used?
9) How long have you been involved with using The Cube in teaching?
10) Would you be interested in attending a focus group or talking to us further?

Focus Group Questions – Academics and Professional Staff

1) Please provide a description of how The Cube has been integrated into your unit.
2) What would you say has been helpful about The Cube for your teaching?
3) What about The Cube has been challenging for your teaching?
4) How in the future could The Cube be beneficial in other ways to your teaching?

Interview Questions - Academics and Professional Staff (based on focus group responses)

1) How do you think The Cube is helpful for teaching?
2) What new ways could The Cube be used for teaching?
3) What advice would you offer to someone using The Cube for teaching?
4) How does educational theory provide insight into using The Cube in higher education?

Focus Group Questions – Academics and Professional Staff (not using The Cube)

1) How do you think The Cube could be used to help you with teaching?
2) What is attractive about using The Cube for teaching?
3) What challenges do you anticipate in using The Cube in teaching?

4) How does educational theory provide insight into using The Cube in higher education?

Focus Group Questions – Students

1) How has The Cube been used in your university learning?
2) What about learning using The Cube was helpful?
3) What was difficult about learning using The Cube?
4) How else do you think The Cube could be used to help you learn.
5) Invite for further comments, by interview or email.

8.2. Participants

Survey

There were 15 survey participants.

Table 1 Survey participants' gender

Female	8
Male	7

Table 2 Survey participants' affiliations

Administrative Services	
Marketing and Communications	1
Business School	
School of Advertising, Marketing & Public Relations	1
Creative Industries Faculty	
Design Lab	1
School of Design	1
Health Faculty	
International & Engagement	1
School of Biomedical Sciences	3
School of Clinical Sciences	1
School of Exercise and Nutrition Sciences	1
School of Optometry and Vision Science	1
School of Public Health & Social Work	1
Science and Engineering Faculty	
School of Biology & Environmental Science	1
School of Information Systems	1
School of Mechanical Medical & Process Engineering	1

Table 3 Survey participants' employment

full-time academic	13
sessional academic	1

learning designer	1

Table 4 Survey participants who had used The Cube in teaching

Yes	4
No	11

Interviews

There were 9 interview participants, some being interviewed together. Many of the interview participants had not completed a survey.

Table 5 Interview participants' gender

Female	4
Male	5

Table 6 Interview participants' affiliations

Administrative Services	
Marketing and Communications	1
International	
QUT Precincts	1
Creative Industries Faculty	
School of Design	1
Health Faculty	
International & Engagement	
School of Biomedical Sciences	
School of Clinical Sciences	
School of Exercise and Nutrition Sciences	
School of Optometry and Vision Science	
School of Public Health & Social Work	
Science and Engineering Faculty	
School of Biology & Environmental Science	
School of Information Systems	1
School of Mechanical Medical & Process Engineering	1

(To be finalised)

Table 7 Interview participants, by interview

Interview	# of participants	Survey #
1	2	12, 10
2	1	16
3	1	
4	1	4

5	1	5
6	2	
7	1	

Table 8 Interview participants who had used The Cube in teaching

Yes	4
No	5