

## Learning-by-Making: High Impact Learning in Design

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**Abstract:** *The purpose of this paper is to describe the role High Impact Learning experiences can have in changing the way that students understand and practice design. At the School of Architecture & Design, the Learning-by-Making program provides such an opportunity, where students collaboratively design, assemble and install small community projects in both 'This Place' and 'That Place'. Students engage in three distinct learning 'spaces': they evaluate, analyse and reflect as individuals, they collaborate, negotiate and take responsibility as a student group, and they engage with diverse world-views in a community space.*

*The paper reflects on the LBM learning and teaching model through the analytical lens of a Threshold concept. The act of collaborative making can be 'transformative' in that it results in irreversible conceptual links between the design idea, fabrication and practice. The conceptual space of the project is clearly 'bounded' by the brief, budget, technology and client requirements. LBM projects are 'integrative' in that they inevitably involve materials, structures, patterns of habitation and climate control. The learning is 'discursive' in that students are encouraged to articulate their opinions on design decisions, both within the student group and with community collaborators. Students' collated reflections and observations provide rich evidence of the reflective value of High Impact Learning and its transformative role in design education.*

**Keywords:** *threshold concept, design pedagogy, experiential learning*

## **Introduction**

Learning by Making (LBM) is an approach to design teaching that has evolved over the past 20 years in the School of Architecture & Design at the University of Tasmania, involving the collaborative design and fabrication of small structures, many of which are installed in public space. Inspired by experiential learning (Kolb, 1984) and the student-initiated projects that were central to architectural education in the 1970s, the emergence of LBM reflected the enthusiasm of both academics and the workshop manager for ‘making’, as well as the establishment of a Centre for Building With Wood within the School which importantly resulted in a new workshop facility. The underlying objective of LBM studios is to create an experience that changes the way that students understand and practice design, in particular strengthening the conceptual links between idea, fabrication and design practice. Individual LBM studios focus on the skills associated with ‘collaborative making’, a group of students taking collective responsibility for designing, prototyping and realising a real design project. The projects number around one hundred and include stage sets, exhibition stands, bus stops, micro-dwellings, play structures and bush installations. The LBM program is recognised nationally and internationally within Architectural education and the profession. This paper analyses the LBM methodology in relation to its potential to deliver High Impact Learning (Kuh, 2008) and does so through the lens of Threshold concepts (Meyer & Land, 2006).

Design is a troublesome concept to teach, as it is varied and complex, difficult to capture in cognitive dimensions (Lawson, 1997, p. 305), and yet easy to recognise. Design is not readily learnt or mastered through reading or instruction. Design represents a devised solution that draws from many domains of knowledge that require a reconciliation of objective and subjective decisions as to what is often an ill-defined problem. Students often experience difficulties with the apparent complexity of the design process and will often default to reducing the process into more easily digestible parts. One of the more common reductions is the separation of the design idea from the realities of construction. Holding the domains of idea and construction simultaneously, in a dynamic balance, is a difficult concept for students to grasp. The difficulty is further amplified by the tendency to teach design and construction in separate units. Attempts have been made to teach design and construction together but the convention of teaching through hypothetical problems or projects cannot effectively highlight the implications that design decisions have on construction. Executing representational design drawings does not communicate the immediacy of the implications for construction and relies on the teacher or tutors’ regular feedback, evaluation and discussion of progress and success.

Understanding the dynamic relationships between design and construction requires a form of High Impact Learning (Kuh, 2008) such as experiential learning, problem-based learning or the traditional apprenticeship model. We believe that by collaboratively designing, assembling and installing small structures in public space, LBM provides an environment for students to directly experience the immediacy of design implications. The emphasis on ‘designing through making’ provides an impartial and tangible feedback to students regarding the success of their decisions or understanding, re-informing their understanding of design. There is no space for ‘bluffing’ gravity. The projects are ‘live’ (distinguishing LBM studios from the conventional hypothetical model). There is a client, a budget, a brief and a site, all of which need to be addressed. Students are exposed to reality, as opposed to a representation of reality.

## **Methodology**

While the core principles of ‘making’ and ‘collective responsibility’ have remained consistent over the past twenty years of LBM the model has evolved, taking on the varied priorities of the staff members involved, practical experiences, mistakes and reflections on student outcomes. While the staff involved in the LBM program are confident that significant learning occurs during the studios we

have become curious as to how this might be analysed and understood within the context of learning theories. Literature related to 'live' student studios (or Design/Build studios as they are more commonly known in the U.S.) has mainly documented the teaching approach, the outcomes and the general impression of student satisfaction. Available literature has seldom moved beyond a basic recognition of experiential learning or problem based learning theory. This is a pattern observed more broadly within architectural education and has caused a few to speculate whether those involved in the 'doing' are more adept and motivated by practice and tacit knowledge rather building than its relationship to learning theories (Fowles, 1984; Lawson, 1997; Webster, 2004). This might also be a reflection of the discipline based knowledge and discourse (Helle, Tynjälä, & Olkinuora, 2006).

This paper applies a theoretical framework to the LBM model in order to gain a deeper understanding of whether this experiential learning environment is capable of fundamentally changing the way that students understand and practice design. Threshold concepts (Meyer & Land, 2006) were chosen as an appropriate framework to begin this analysis as it originated from a research project to strengthen learning and teaching in undergraduate courses within the discipline context (Cousin 2006a; Boys 2011). It provided a way for educators to focus and identify what were the barriers in student understanding and methods to overcome. A Threshold concept was considered to be "...akin to a portal, opening up a new and previously inaccessible way of thinking about something" (Meyer & Land, 2006 p3).

The 'live' characteristics of the LBM studio expose students to new modes of design thinking and can be related very closely to five of the most common characteristics attributed to Threshold concepts: *transformative, irreversible, integrative, bounded and troublesome* (Meyer & Land, 2006). These characteristics form the framework to analyse LBM, as well as locating the places of learning, both in a physical sense and in a social and learning sense. In a physical sense LBM projects are designed and fabricated within the School workshop ('this place') and are procured and installed within the local community ('that place'). In a social and learning sense students engage in active, social and creative learning (Phillips, 1995) in three distinct 'spaces': they evaluate, analyse and reflect as individuals, they collaborate, negotiate and take responsibility as a student group, and they engage with diverse world-views in a community space.

A Mixed Methods Research approach is used and employs a pragmatist worldview, where the focus is on investigating the problem and draws from available and plural data collections, such as students' reflective journals and assignment work, teachers' observations and notes and stakeholders' feedback (Creswell, 2011). We have used several examples of LBM projects and quotes from students' written assignments to illustrate the development of conceptual links between design idea, fabrication and practice. The scope of LBM units examined is from 2013 to semester 1, 2014, and involved five units with an average cohort of 19 students (Ethics Reference Number: H0014468). These students choose to undertake LBM as an intermediate or advanced elective as a part of their architectural studies. This paper reflects the beginning of an analysis of LBM through the lens of Threshold concepts. Future research will map trends occurring in cohorts and place a greater focus on practices to overcome recognised learning barriers.

### **Transformative**

The *transformative* characteristic of a Threshold concept reflects the change that occurs when a student understands a new way of thinking and/or practicing the discipline subject matter (Land & Meyer, 2006). In the context of the LBM program the students' understanding of the design process is transformed through direct experience of making, constructing and collaboration. The 'conventional' design studio cannot mimic the translation of ideas into materials and spaces, which lies at the core of the designer's experience. Despite strategies to link design and construction units students routinely resist or delay the integration of construction into a design response.

It is argued that LBM studios highlight the links between the various characteristics of the design process: the evolution of an initial design idea; the properties of materials and how they are connected; the specification of components; the fabrication of elements and the subsequent use of the space or object. Once a student has experienced an idea being translated into reality, a fundamental change has occurred in the way he or she sees the discipline and the act of designing. The magic of a line or scale model being converted into a full-size physical object cannot be underestimated. Making occurs in both ‘this place’ (School Workshop) during design development, prototyping and fabrication and in ‘that place’ (Community site) when installed.

*I find it hard sometimes to spend weeks in the design process to then present your design, and then the plans go in the bin. After seeing a design built hypothetical studios where work is put in a portfolio and forgotten are a let down. (Second year domestic student A, 2013)*

*The fact that every single detail of this small object had to be resolved reveals the delusion of the oversimplified design processes in other studio assignments. We understood that the other half of the project is to see how it can be pushed to 1:1 scale with real material. (Third year international student B, 2013)*



*Figure 1. The installation of an Outdoor Learning Space in Trevallyn (2014) (left) and an observation platform in the Styx Valley (2001) (right)*

In contrast to ‘conventional’ design studios, which emphasise the individual student, LBM studios encourage teamwork and collective responsibility. Perspectives of students working individually are not easily challenged and the traditional review of work, known as the ‘crit’, provides limited opportunity for students’ active involvement. The structure of an LBM studio typically involves rapid cycles of making, followed by collective discussion and goal setting. Students are encouraged to lead discussions and are given the skills and confidence to take responsibility for the project.

*I believe that my skills in team leadership increased dramatically through having to sometimes take charge to get a task completed. (Third year domestic student C, 2013)*

Working with client bodies has exposed student groups to a range of world-views, including youth at risk of homelessness, primary and high school students, work-experience trainees, teachers, actors and artists. ‘That place’ provides confronting and enriching experiences for students. Three strawbale projects (2001-2002) at the Mount Arthur Centre involved a group of predominantly international architecture students working alongside rural Tasmanian youth. The Ravenswood Skatepark (1999) was designed in a vacant shop in the neighbourhood shopping centre. Architecture students, acting under the auspices of the Ravenswood Walk Tall Association, invited involvement from the community. Community youth members were encouraged to make and install models of their preferred skating features. A TV/video was also provided in the shop for youth to view and discuss

their skating videos. Samuel Mockbee, the Director of Rural Studio (a globally respected Design/build program at Auburn University) suggests:

*What we should do is go into their world and understand it. They go out there with pre-conceived ideas, only to discover that they gonna learn something from these people. (Big Beard Films, 2010)*

The transformative impact of LBM is not restricted to design students. The Flying DuckSeat (1997) at the Campbelltown District High School was installed in a circus-like atmosphere of music and lights, witnessed by many of the school students who had been actively involved in its design. The Castle (2007-), a long-term collaboration with a neighbouring youth shelter provides crisis accommodation to youth at risk of homelessness through the deployment of mobile micro-dwellings, giving the young person an option to maintain social networks. In addition, long-term unemployed youth are trained to assemble The Castles, gaining construction certificates and improving their future employment prospects.

### **Irreversible**

Threshold concepts are difficult to unlearn. The learning may be modified, but the core knowledge remains intact and the student is unlikely to return to previous modes of thinking (Land & Meyer, 2006). The Design Report assignment in an LBM studio is an opportunity for students to reflect on their learning, by articulating their perception of the experience, and create stronger links in their construction of knowledge. Students express the value of reflection when compiling their report. A student writes, “At least I realise now that I enjoyed the process and learnt more than I realised at that point in time.” (Third year domestic student D) The four LBM learning outcomes – speculation, collaboration, communication and making – are used as the basic structure for the Design Report.

Students also refer to the learning that comes as a consequence of making mistakes. “An important attitude that I personally still need to improve is instead of being afraid of errors, I should look for errors, embrace their existence and tackle them.” Another student titles his Design Report “10 Lessons Learnt by Making Decisions and Mistakes as a Group”. Within the report it recommends that,

*The best strategy is learning from mistakes. By making mistakes and realizing that something went wrong is a natural learning ability that everyone possesses ...The value of mistakes made in the design process is what this course is treasuring the most, since failure is the mother of success, so don't be afraid to make mistakes in the designing stage. (Third year international student C, 2013)*

Students have referred to the acronym LBM as being Learning-by-Mistakes. The mistake and the subsequent remedial action are seen as a critical opportunity for learning, both by individual students and the studio as a whole.

### **Troublesome**

*Troublesome knowledge* (Perkins, 2006) is characterised as being difficult to understand. Trouble may be experienced if it is any of the following: ritual (routine); inert (recalled knowledge not actively used); conceptually difficult; alien (conflicts with own perspective); or tacit (related to a specific community of practice) (Perkins, 2006). Trouble is further experienced by the use and meaning of discipline specific language and the episteme, the way to understand or act within the discipline. All these characteristics of troublesome knowledge can exist in LBM studios.

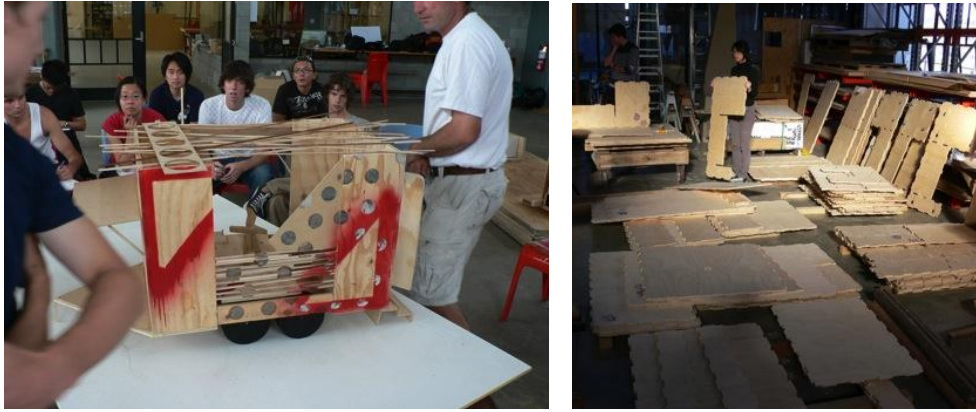


Figure 2. Overwhelming impact of moving from rough concept model through to full-size components



Figure 3. Translation of drawing into digital model into physical object and panel testing

For many students, their identity within the student group is fragile and collaboration can be troublesome. Their roles and their relationships with other students may be problematic, uncomfortable or even traumatic (Cousin, 2006). If the ways they relate and belong are put under scrutiny, either by themselves or by others, students will find other aspects of studio content – questions of practicality, creativity and interpretation of client requirements – much more challenging. If not handled carefully by the facilitator contests over design direction within the studio group can be damaging, both to individuals and to the studio as a whole. The facilitator must ensure that the LBM studio is an emotionally safe environment, that students don't feel left out, affronted or exposed. Ownership of ideas by individuals is kept to a minimum and facilitators role-model decision-making approaches. Some students find interaction with community collaborators confronting, whether communicating with primary school children or homeless youth. This can also present a barrier to learning unless students have an opportunity to debrief and to be supported in a subsequent meeting.

There are several troublesome aspects for LBM facilitators. Firstly, the Design Reports (critical reflection) only provide evidence of students who have become self-aware of the changes the new learning has had on their understanding of the field. We believe there are students who are not aware that their experience has been transformative. The question this raises is whether self-awareness of the mastery of a Threshold concept is important? Is the new learning more likely to be irreversible if the student is self-aware? Perhaps this is what Land and Meyer (2006) refer to as a state of 'liminality', that students appear to become 'stuck' within the Threshold, neither passing through or going back. Another example of 'stuckness' is where students have had a transformative



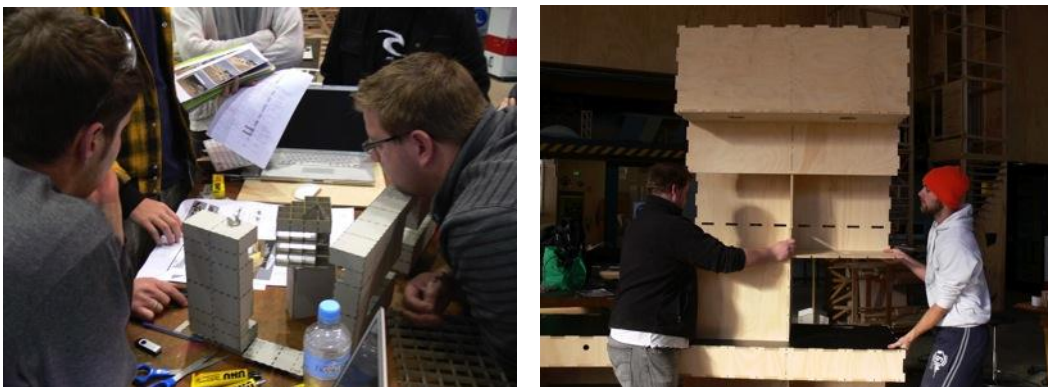
experience, as documented in their Design Reports, but are unable to apply the new knowledge in other units. First year students build a small shed using traditional timber frame construction but many find it difficult to translate that knowledge to an assignment the following semester where they are asked to document the same construction system. It is possible that for some self-reflexive learners it may take time for the full outcome of the High Impact Learning to be formed. Samuel Mockbee believes that delayed response happens to many Rural Studio students.

*All these students, as they become successful, when they finally get registered and they really are leading the life of an architect that that's when they'll say "look! I wanna do something like when I was at back at the Rural studio. I wanna regain that sense of wonder." so these students are getting an opportunity to produce this kind of work, within this little frame of their careers that will ultimately blossom, at some point I do believe, down the road... (Big Beard Films, 2010).*

### **Integrative**

Threshold concepts involve integrating or synthesising knowledge that was previously viewed to be unrelated (Land & Meyer, 2006). As described above, LBM studios integrate designing and making. Typically LBM projects involve multiple co-dependent design considerations including materials, structures, patterns of habitation and climate control. Even a simple bus shelter - several of which have been constructed by LBM studios - involves consideration of all these issues. In addition to these The Castle project (2007-) required an acute consideration of patterns of habitation: servicing, insulation, bathing, openings, privacy and storage of belongings. The Teardrop caravan (2014) required that most attributes of a dwelling – including plumbing, electrics, cooking – to be incorporated within a couple of cubic metres of habitable volume. These micro-domestic environments are excellent vehicles for students to explore interrelated aspects of design.

Physical models are the preferred design medium, due to their ability to communicate information in a relatively direct manner. However students are encouraged to use a variety of other media. The whiteboard remains a highly effective tool for collaborative design. Digital manufacturing offers exciting opportunities to further integrate design and making. A 'home-grown' software plug-in has enabled rapid prototyping of objects fabricated from sheet materials. Students find the combination of digital and physical modelling empowering, narrowing the conceptual gap between the designed object on the screen and its scaled or full-size outcome. Students are encouraged to red-pen, cut or add to digital models, adapt the electronic model and print a new physical model.



*Figure 4. Combination of design media ... through to full-size fabrication.*

The facilitator role is to assist twenty individuals to synthesise their ideas into a single buildable outcome. Ownership by the whole studio is critical in maintaining collaborative energy, responsibility and teamwork. Ideas are gradually coalesced, edited and distilled until the facilitator senses that a

single model can embody the studio aspirations. Timing and balance are critical. The facilitator must be confident that ideas can be integrated without some students feeling isolated and simultaneously avoiding the dangers of 'design by committee' where too many discrete ideas are forced to live together.

*When I look at the finished object I can see that my idea had been included, but in a way I hadn't thought of. (Second year domestic student E)*

### **Bounded**

The *bounded* characteristic (Land & Meyer, 2006) primarily assists students to familiarize themselves with discipline boundaries but also has a role in assisting staff in setting appropriate parameters for both curriculum and individual projects. LBM began as an elective option in the undergraduate degree (1994) but now has a presence in three years of the undergraduate program, and both years of the Masters of Architecture. LBM project typologies are based around technology, community, research and professional development. Projects are placed within the Architecture program according to required learning outcomes and level. Generally speaking undergraduate projects are very tightly *bounded* – first year students build a shed using traditional timber frame construction - while Masters projects are much more open-ended and incorporate research. The Playbox (2014), commissioned by the Tasmanian Catholic Education Office and undertaken by final year Masters students, involved the development, design and fabrication of a relocatable object that encourages imaginative play for Primary School Students. The project initially involved research into the theory of 'loose parts' (Nicolson, 1971), which promotes the use of random universal objects for creative play.

The external boundaries of a particular LBM project are given by project brief and the budget. The brief determines the performance requirements of the designed object/space and the budget determines the approach. Together they create a conceptual space for learning. Internal boundaries, relating to technology and project timeframe, are determined by the studio facilitators and serve a specific and limiting purpose. The Trevallyn Primary School Outdoor Learning Space (2013) opted for a technology based around milk-crates, chosen for their building-block qualities, colour and their potential use as stools and plant pots. The choice of the milk-crate narrowed the scope of decision-making, allowing students to focus on other design issues. The duration and intensity of a project – either thirteen consecutive days or thirteen weekly classes - may be based on a desire for either maintaining intense energy or time for reflection.

Compliance, in terms of planning, structural adequacy or safety, forms another layer of external boundaries for LBM projects. Engineers support students in the development and evaluation of their design propositions. A response to Workplace Health and Safety (WHS) has been to integrate risk management into LBM, to the extent where it is an assessable criteria. Students are required to check compliance requirements, compile necessary documentation and communicate with relevant authorities and engineers.

*After extending our knowledge on the specifications and regulations we had a more informed and realistic approach that we hope affected the design process for the better. (First year domestic student F)*

A notable exception to the bounded studio was an LBM where students were encouraged to 'phaf', play or tinker, resulting in more serendipitous propositions. This approach is underpinned by creative exploration and requires a deep understanding of materials before formal design commences.

Students numbers in LBM studios – typically less than twenty – are lower than many core units which is probably a noteworthy boundary. The recent incorporation of some LBM approaches into core



units brings with it some potential hazards, particularly in collaborative learning, due to the much larger numbers of students. There is evidence to suggest that the LBM model becomes clumsy and unwieldy when the numbers approach fifty. Groups of twenty or less allow the whole studio to collaborate effectively. The other consequence of larger student numbers is multiple facilitators, which may bring its own difficulties.

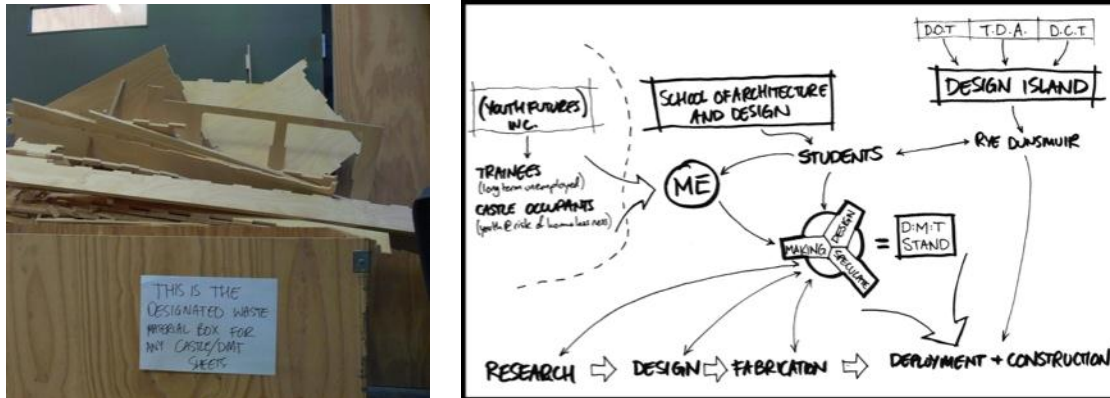


Figure 5. Waste collection for calculation (left) and student diagram of stakeholders (right).

### Discursive

Land & Meyer (2006) make reference to the role that enhancing or extending discipline language can play in mastering a Threshold concept. In LBM studios, students are required to develop their communication skills and language use in ‘this place’ - the student design team and in ‘that place’ – with community clients.

Students in LBM studios express their enthusiasm for a particular design perspective with a passion that is less evident in ‘conventional’ design studios. Some articulate their points of view persuasively because they want their own ideas to be built. Others have developed a sense of responsibility for the project and are willing to go the extra mile in order to earn respect from the client. Students with a practical mindset understand the implications of taking an idea to its built reality and argue for the simplest solution. Several techniques are employed to exercise the students’ ability to communicate. The membership of groups is kept fluid, ensuring that students communicate ideas to a range of peer groups, meaning that ideas permeate through the entire studio and that ideas cannot be defensively ‘owned’. Students’ reflections often focus on the dynamics within the studio.

*... students were guided rather than directed, leaving the responsibility up to us, simulating a real-world studio environment. At times this was an exasperating experience, when stubborn personalities cling to irrational ideologies that restrict progress. However, as the semester progressed it became apparent to me that rather than the physical model, managing group politics was the most valuable learning outcome. This included working in a team and knowing how to appropriately and positively contribute to a group discussion. (Third year domestic student G, 2014)*

*We were inevitably headed for a crash at some point. But when it came, it actually clarified things. It was such a relief to finally hear the real reasons behind some of these ideas and critique them honestly. Sure there were nearly some deaths, but the afterglow was certainly worth it. (Third year domestic student D, 2014)*

Listening and observing are important skills for a designer. In community-based LBM studios students are encouraged to be conscious of the verbal, spatial or graphic vocabularies their community collaborators use.

*The most notable difference when comparing differences between Architecture and Primary School students was the choice of words when describing elements in design. The Trevallyn students were able to effectively and clearly articulate their design ideas and concepts to other primary school students and to us architecture students. The Trevallyn students were easier to understand and were able to communicate their ideas with more clarity than most architecture students.... (Third year domestic student C, 2013)*

Another tool that assists communication amongst peers and community clients is the use of physical models. It has been found that models are most effective to communicate complex design ideas and remove ambiguity. Models are used in discussion from the concept through to the final presentation. LBM studios have developed model-kits as a common language between designers and community collaborators. Models are equally useful for collaborative design and understanding construction.

The models were a great way to interact with the children, and were very successful in deriving design ideas made by the children. (Third year domestic student H, 2013)



*Figure 6. Model workshops with School students and final model including digitally fabricated components and elements made and painted by School students.*

## **Conclusion**

The success of the LBM program, in terms of the quantity and quality of the built outcomes, is indisputable. The client feedback is consistently favourable, the structures have had an enduring positive impact on the amenity of many public places and the projects have touched many hundreds of people, either through participation in making or through subsequent use. LBM has become an invaluable asset to the School of Architecture, in terms of community engagement and is a highly visible manifestation of the School's professional and educational values. However, the educational outcomes of the LBM model have been more difficult to evaluate. One strong indicator of perceived educational benefit of the LBM model is how several of the program's core characteristics have recently begun to permeate other units within the School of Architecture & Design, including the 'conventional' design studios. From its beginnings twenty years ago as a single undergraduate elective the making-based collaborative studio now has a representation in every year level of both undergraduate and masters' courses. The attractiveness of LBM or High Impact Learning to staff has been the levels of student engagement and the quality of the design outcomes.

While it has been possible for several years to form a generalised opinion as to the educational benefits of the LBM model it has been the purpose of this paper to make a more objective evaluation of the learning outcomes, and to do so through the vehicle of Threshold concepts. The evidence presented here indicates that LBM studios consistently involve High Impact Learning and that the experiential content of the LBM model encourages many students to cross the Threshold concept, reinforcing their understanding of the links between idea, fabrication and design practice. Through students' reflections we can see that the primary transformative characteristics of the LBM program are as follows: the process of translating idea into reality; the ability to take risks and make mistakes; taking collective responsibility for decisions and their outcomes; the integration of varied types of thinking; the careful choice of communication media and language. We have also found that one of the most effective attributes of the LBM studio is that the place of learning is not restricted to the self-affirming environment of 'this place' - the School of Architecture & Design - but that LBM takes students into 'that place' where students and staff alike are confronted by diverse world views and expectations, further developing their construction of knowledge.

On the basis of this initial analysis of LBM using the lens of Threshold concepts we have identified some key issues to address. The first is to improve the quality and quantity of the data, meaning that we can more effectively and more accurately gauge the transformative and irreversible impact of the LBM model on students. The Design Report assignment (based on students' reflections of the LBM experience) is a good starting point but it could be more effectively targeted, requiring that students make explicit reference to the ways that they have acquired and applied new knowledge. The structure of the Design Report - currently based on the unit Learning Outcomes of Collaboration, Speculation, Communication and Making - could be extended to include more specific questions relating to our own knowledge gaps. For example, how knowledge learnt in LBM might be more effectively applied to other units, as students seem to find it difficult to integrate the new knowledge within a different learning environment. With such data we would be in a better position to develop the LBM model towards an overall aspiration that a greater proportion of students experience an irreversible transformation.

We believe that while the LBM studio provides an environment conducive to passing through Threshold concepts, for some students this may still take more time. This paper reflects our first inquiry of evaluating LBM using a theoretical framework, and there are many more opportunities afforded. The next phase to be reported are the trends across the cohorts, and later, the facilitation role to support students who experience 'stuckness'. This paper has highlighted the benefit of High Impact Learning in teaching design, both at 'this place' and 'that place' and generated new energy to learn more.

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