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This report describes the theory and research literature that underpin Smart Learning (SL) including a description of the context and need for the initiative. It describes the way multiple bodies of literature intersect in the theory, design and practice that drive SL in five areas. They are:

**Context and Need:** The context for Smart Learning is addressed in two ways. The first describes the uncertain circumstances surrounding the sector at this time that creates a context and need for initiatives like SL. The second examines the existing state of readiness for curricular reform in higher education.

**Theoretical Framework:** The theoretical basis for Smart Learning and the literature associated with that theory.

**Learning and Teaching Research:** The literature that provides Smart Learning content. This work is employed to design the systems, methods and tools involved in the initiative.

**Efficacy Research Underpinning Smart Learning:** The research applying the theory in K-12 and higher education.

**Edge Technology:** The research and practice that underpins the design of Smart Tools (ST) and the approach to emergent feedback and analytics.

**What is Smart Learning?**

Smart Learning is a multi-year transformational organisational change initiative to build and implement a sector leading learning and teaching model and online learning strategy at Charles Sturt University (CSU). This includes:

1. Building a new way of designing, developing, implementing and evaluating courses.
2. Creating a software system for learning design, development, implementation and evaluation.
3. Developing a new regulatory and approval process for securing and maintaining courses of the highest quality.
4. Developing a new organisational design to support the learning and teaching model including:
   a. Employing the University Implementation framework and collaborative process to embed the approach in the normal work of CSU.
   b. Embedding the model in the role descriptions of Course Directors, Educational Designers, Course Teams, Team members and Divisional staff.
   c. Embedding the model in the Promotion Process.
5. The development of a new teaching and learning analytics system that can both drive and integrate with the broader University strategy.

In collaboration with the CSU community, the Smart Learning Initiative is developing the technologies, systems, organisational design and implementation methodology required to make CSU a legitimate leader in the higher education sector.
What are the Expected Outcomes of Smart Learning?

- Improved capacity to compete in a new more competitive online market landscape.
- Improved performance on sector and University measures of student satisfaction.
- A new sector leading model and delivery approach for online learning.
- Sector leading course design and implementation at scale based upon the implementation of the CSU Learning and Teaching Model.
- Improved workforce capacity in learning and teaching.
- A sector leading organisational structure and regulatory process for course design, implementation and evaluation.
- A high-value system of feedback and analytics that provides CSU with the capacity for continuous change and improvement necessary to sustain leadership in learning and teaching.
- A proprietary international sector leading technology system (Smart Tools CourseSpace, WorkSpace and Analytics).
- An outreach capacity and potential around the disseminable/marketable features of the CSU model and associated technologies.
- Charles Sturt University positioned as an international leader in learning and teaching with a specific focus on online learning.

Context and Need

Serious and fundamental questions are being posed about the future viability of Australian universities. These questions relate to rapid change in the way learning and teaching is delivered, the globalisation of the university market, and increased competitiveness in the online space (Bokor, 2012). The direction universities take in answering these questions has consequences for their design, their staffing, the way they create and deliver their teaching and learning programs, and the way they compete with each other. The context and need are addressed through two perspectives – the sector, and the state of course design and development.

The Sector

According to proponents of transformational change, the future services offered by universities will exist in a national and global marketplace instead of a state and regional one, and more often in a virtual as opposed to bricks and mortar delivery model (Harden, 2012). Charles Sturt University is a major national player in online learning, with a business model and University strategy that is driven by its strong presence in the online market where it is facing increased national and possibly global competition.

While the drivers for change in the sector have existed for some time, there is an undoubted increasing cadence in the debate and a demonstrable sense of fear driving a call for action within universities and across the sector. The possibility of a new paradigm of university education is a serious conversation. The drivers have been amplified by the recent proposed Budget (The Commonwealth of Australia, 2014) which portends a significant shift in the way Australian universities will be funded, the way fees will be determined, and the ways in which universities will be required to position themselves in a demand-driven system (Kemp & Norton, 2014).
Whether these changes transpire in the immediate term is unclear, however a more deregulated, demand-driven and user pays approach to higher education seems to be a direction in which Australia’s higher education system is headed.

One of the most compelling findings of the recent Kemp and Norton Review (2014) is the way a demand-driven system and consequent changes in the enrolment profile co-varies with higher student attrition and lower rates of progress. When compared to the US (an example of a longstanding demand driven system), Australian attrition rates are relatively low in line with the lower percentage of students who participate in University education. In the US, nearly half of the students who begin university fail to complete in six years (U.S. Department of Education, 2014a). The annual average cost of an undergraduate degree at a public institution in the US (including out of state loading) is approximately US $20,000. The relatively low graduation rates and ever-increasing cost creates a wicked problem whereby more students carry high levels of debt for a qualification that in nearly 50% of cases is incomplete. College loan debt in the US is currently 1.2 trillion dollars with an average debt load of US $29,400 per student (The Institute for College Access & Success, 2014). 13.7% of US students default on their college loans (U.S. Department of Education, 2014b). The US college debt load is widely recognised as an impediment to US economic growth (Peterson-Withorn, 2014). Similar concerns have been raised in the United Kingdom (UK) where the Higher Education Commission has expressed significant concern “about the future level of student debt with financial experts estimating that 73 percent of all students will still be unable to pay off their loans after 30 years, when debts are automatically wiped” (Garner, 2014), with the average student debt around £44,000 (approximately AUD $79,000). While Australia is yet to encounter this problem at the levels currently experienced in the US and UK, it is a likely outcome in a more deregulated demand-driven Australian higher education market.

The student performance data described in the Kemp and Norton Review (2014) indicates the risk of a US type high-cost—high-attrition—high-debt scenario will be greater for those universities that enrol a more heterogeneous student body and experience higher rates of attrition as a consequence. While in a deregulated system the initial costs and consequences of deregulation will be borne by individuals and ultimately the broader economy, many institutions are likely to face immediate impacts related to higher attrition levels as they seek an increasingly heterogeneous student body in order to fill their enrolment targets. These institutions will incur the substantial costs of replacing those students who leave mid-degree or the possibility that they will not be able to do so.

When an institution’s market share diminishes in a deregulated environment, it is more likely to entertain tuition discounting in response. An article in Forbes Magazine entitled “Tuition discount alert: 50 great colleges desperately seeking students” (Schifrin, 2013), serves as an educative example of this phenomenon and the palpable connection between market share and tuition in the US deregulated system. This is an important observation. The Australian deregulation conversation has not focused on the dynamic way tuition cost could be influenced negatively by factors in the market that are outside of the short term control of the institution. What Kemp and Norton (2014) and the US experience shows, is that student heterogeneity and the institution’s response are likely be linked much more viscerally to a university’s viability in a deregulated market.

The State of Course Design and Development

The climate of change and uncertainty in the sector has heightened the focus on learning and teaching. This includes concern about entry and exit standards, participation (Bradley, Noonan, Nugent, & Scales, 2008), issues of equity and inclusion (Devlin, Kift, Nelson & Smith, 2012), and quality assurance (TEQSA, 2012). The need to address these concerns is reflected in a range of initiatives that include projects to track and predict student performance and success, the innovative use of technology, and external benchmarking (Kemp & Norton, 2014) and the measurement of student satisfaction and performance.

According to Cherastidtham, Norton and Sonnemann (2013), the need for good teaching in Australian universities has never been greater. Good teaching begins with a strong responsive curriculum. The Bradley Review (Bradley et al., 2008) challenged all Australian universities to view the push for increased participation in higher education
as a driver for curriculum reform. With current curriculum reform promoting the importance of catering for the needs of individual students across all disciplines, changes in the design and delivery of courses are also necessary.

What is not evident nationally and internationally at this time are coherent and integrated approaches to the broad-based fundamental transformation of universities to address the tensions and challenges associated with becoming better learning organisations. This includes the simultaneous transformation of policy, work practice, organisational design, technology, and support around learning and teaching that are commensurate with the order of magnitude of the challenges facing universities. How university courses are designed has not been addressed through reform, although traditional design methods have been widely criticised (Florian, Rouse & Young, 2010; Forlin, 2010; Song-Turner & Willis, 2011).

Four areas of need have been consistently identified in the higher education literature related to course design and development. These are: the need for a theoretical basis for course reform and design (Goldspink, 2007; Levin, 2010); the need to close the theory-to-practice gap between (a) research in higher education, and (b) what is done in practice (Hora, 2012; Norton et al., 2013; Song-Turner & Willis, 2011); the need to utilise collaborative practice, including the way groups of people worked together to achieve common goals (Burgess, 2004; Furlonger, Moore, Sharma & Smyth-King, 2010; Hyun & Oliver, 2011; Winn & Zundans, 2004); and the impact of institutional practice on course reform, design and innovation (Bradley et al., 2008; Levin, 2010; Oliver, 2013; Sabri, 2010).

A number of researchers have identified the need for curriculum innovation to be theorised beyond actual curriculum content (Cochran-Smith & Zeichner, 2005; Hoban, 2004; Kezar & Lester, 2009). This refers to the kind of theory that links design process to the full scope of the change required by organisations to engage in substantive and sustainable curriculum reform. Such theory addresses the way the organisation is structured for learning and teaching, as well as the content and process specifically related to the design of curricula. It is clear that unifying theory is necessary to bring these interdependent aspects together.

There is also a gap between research and practice with the most prevalent explanation suggesting that researchers and practitioners operate within quite different cultures (Kezar, 2000; Schalock, Schalock & Ayres, 2006). Kezar (2000) suggests that the dichotomy between theory and practice is a social construction. Within the institutional context, theory is broadly constructed to mean work that is done in research, principally in university settings, that in turn is expected to impact upon the field. However, this fundamental operating assumption of universities has not been applied to the field of curriculum learning and teaching in higher education where innovations are rarely theorised and only loosely connected to related research.

Multiple factors come into play at the higher education level that continue to separate theory from practice - the culture of the institution, socialisation of the faculty, the discipline foci of the institution, and the continued tension within higher education itself as a professional identity (Kezar & Lester, 2009). This suggests that addressing the theory to practice gap requires high-level and broad-based change capable of engendering new cultures of practice. Those new cultures need to address the separation from practice (Grima-Farrell, 2012) and reconcile the acquisition of practical knowledge with traditional theoretical knowledge (Berry, 2007). From a Smart Learning perspective, the magnitude of the gap in all sectors of the education field is indicative of a field that is pre-paradigmatic in its development and evolution. The reconciliation of theory and practice is necessary for any theory to be complete and for practice to be informed.

Successful and long-term change requires collaboration, yet higher education is often a solitary and isolating profession, with university structures separating disciplines and individuals within disciplines. Kezar and Lester (2009) described the conditions required for a higher education institution to support collaboration. They found that teaching, research, governance and management all needed to be altered to support the collaborative process. Collaboration, and the process required for effective collaboration, can be viewed at several levels: collaboration at the institutional level where academics work together; academics in a specialist field working
together to create and develop new course content; collaboration in the field; and collaboration between educators in different contexts, such as between academics and teachers (Zundans-Fraser, 2014). Cherastidtham, Norton and Sonnemann (2013) indicate that, despite recognising the benefits of collaboration, teachers in Australian universities continue to work largely in isolation.

Brandon and Knapp (1998), suggest that the institutional practice of universities also impedes curricular reform. The authors identify four prominent features of university structure and institutional practice that impede innovation. They are: The knowledge-centric nature of the organisation, position hierarchy, promotion systems and departmental autonomy. These factors interact in ways that perpetuate the status quo by making collaboration and organisational coherence difficult. They create insurmountable challenges for academics attempting anything a little different and innovative while perpetuating “private practice” work environments that inhibit collaboration. The result is often loosely coupled (Weick, 1979) course structures and pathways that lack the cohesion and developmental trajectory students need and want within a course experience.

When a level of flexibility is sought against centralised control within this complex environment (Knight, 2001; Macdonald, 2003), the enthusiasm for self-organisation demonstrated by educators is dampened at administrative levels due to concern about potential risks that may never eventuate (Goldspink, 2007); and when the greatest focus is on rationalisation and efficiency (Coate & Tooher, 2010). These concerns reflect the tension that exists between the organisational structure and realities of higher education institutions and their daily operations. The everyday restrictions and constraints of higher education practice, such as tight deadlines and expansive documentation requirements, appear to work against curriculum coherence and depth. The institutional practice of many institutions focuses on documentation requirements that are not related to the quality of learning and teaching (Zundans-Fraser, 2014) and where ideas of quality are shaped by the extant demands of the organisation around the way curriculum is developed and documented (Borko, Liston & Whitcomb, 2006; Tudor, 2006). Curriculum reform and design that goes beyond the regular institutional cycles of student evaluation, staff reflection, and the selection and design of new subject materials is particularly challenging, as it requires time and dedicated participation that some researchers claim are not a natural part of higher education culture (Burgess, 2004; Hyun & Oliver, 2011).

An integrated course design approach, a more rigorous theoretical base for course reform and tight coherence between course work and practical work are required (Darling-Hammond, 2006; Darling-Hammond, Grossman, Hammerness, Rust & Shulman, 2005).

This overview of key course development issues indicates that reforming curriculum design and delivery involves transformational change in the way universities are structured and organised. Existing processes are not only frequently incompatible with change and better practice, but can actively undermine such change through diffusion of purpose, poor alignment of goals and process, and contradictory structures for reward and recognition. Even though there has been a dramatic increase in educational reform efforts over the past 25 years, it is having insufficient impact to drive sustainable and scalable change (Hopkins & Levin, 2000). Many academics instrumental in curriculum reform are open to innovations, change, and enhancing teaching and learning. However, reform often gets in the way by focusing on structural aspects of the system – governance, finance, workforce and accountability that do not support curricular innovation. A key contention of Smart Learning is that curricular reform needs to drive structural improvement through complete theory to practice models of institutional change for better learning and teaching.

In summary, fundamental change in the way university services are funded, designed and delivered, and the needs and characteristics of the students who pay for and receive the service are driving reform and change in universities that frequently lack the theoretical frameworks, institutional process, practice and collaborative cultures required to address the profound changes they face.
An assumption of this document is that given the context described above, CSU cannot continue with its existing model of Course Design, Implementation, Regulation and Evaluation and be successful in the medium and long term.

Smart Learning is based on three additional key assumptions that relate to the current drivers and context within the sector. They are:

1. Universities must make profound improvement in the universal design and delivery of all learning and teaching to respond to increasing student diversity.

2. The improvement must be demonstrable at scale. Viability will be linked to the quality of the individual student experience at scale.

3. Realising such improvement will require transformational change in the way universities are constituted for learning and teaching.

The Smart Learning Initiative exists because the best way to succeed in this uncertain and changing landscape is to develop a sector-leading model of learning and teaching that will produce better courses and subjects, greater student engagement, increased market share - especially in an online environment, market leading technology tools, and generate brand leverage through differentiation and leadership in the field. Smart Learning is about making the CSU name and learning experience synonymous with successful student outcomes and leadership in learning and teaching. This requires transformational performance changes that extend beyond course design within the institution at scale and a significant culture shift (Dreengenberg, 2013). That culture shift focuses on the CSU model of learning and teaching as the pivot for any consideration of delivery mode, access issues and the role of technologies.

**The Smart Learning Model**

Smart Learning is about transforming learning and teaching at a whole of university scale. Smart Learning is an interaction of theory, research, organisational design and process working interactively to produce better learning and teaching.

Figure 1 is a high-level representation of the way theory, research design and implementation process interact in Smart Learning. The diagram highlights an intentional, dynamic relationship between theory, research, design and organisational process. The subsequent sections of the report describe the content in each area and the interaction that defines the approach.
Theoretical Framework

Universities are often criticised for a failure to apply theory to the design and conduct of their own activities (Allen & Wright, 2014; Coate & Tooher, 2010; Fitzmaurice, 2010; Hoban, 2004). Kurt Lewin said, “There is nothing so practical as a good theory” (Cherry, 2014). Smart Learning adheres to this maxim. From a Smart Learning perspective, theory is more than a set of ideas used to account for a phenomenon of interest. According to Kuhn (1996), the explanatory value of a theory stands at the confluence of its concepts, beliefs and the methods, systems and tools employed to articulate those concepts and beliefs in practice. In Smart Learning, theory is a practical tool, used for model building and articulating the way things happen. From a Smart Learning perspective, theory should generate models of practice that influence the essential function of an organisation or system not just the way it articulates intents or the way it is managed. Getting to scale with an innovation is also related to the role of theory. The efficacy of a theory can be seen as an expression of its capacity to generate a scalable solution to a problem or need in ways that resolve more issues than prevailing theories or approaches.

The theory of self-organisation and self-organising systems (Juarrero & Rubino, 2010; Kauffman, 1995; Prigogine & Stengers, 1984; Prokopenko, 2013; Waldrop, 1993) underpins the Smart Learning approach. Self-organisation is widely documented as an explanatory framework for systems in nature (Juarrero & Rubino, 2010; Prigogine & Stengers, 1984) and those involving human action and intervention including cities (Johnson, 2001), economies (Krugman, 1996), businesses (Pascale, Millemann & Gioja, 2000), schools (Bain, 2007) and the design of technology systems (Bain & Weston, 2012). Self-organisation helps us to understand the non-linear and complex function of systems (Merry, 1995). It indicates that systems are capable of powerful bottom-up change when those systems share a schema or framework for action (Gell-Man, 1994). With a shared schema, the system can disperse control to those agents. Empowered by their feedback and self-organising activity, the system can succeed, grow, adapt and change without constant top-down intervention. Theories of self-organising systems have generated great interest in many fields including education because they provide metaphors for change and adaptation without the constant top-down intervention associated with traditional management models (Scott, 1991). They have a particular allure for education from two perspectives. First, they are frequently used to explain the complexity and often chaotic state of educational organisations (Morrison, 2002) and second, they offer the possibility of better ways to share feedback, disperse control, distribute leadership, and innovate in those

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1 The Smart Learning Interact site includes a broad range of sources describing self-organising and complex systems.
systems. In Smart Learning, the role and contribution of self-organisation extends beyond the metaphorical, to the application of six design principles extracted from accounts and descriptions of self-organising systems, to inform the design of educational organisations (Bain, 2007). These six design principles are:

**Simple Rules or Commitments:** In self-organising systems remarkably complex behaviour can be stimulated by relatively simple rules (Bain, 2007; Seel, 2000; Sull & Eisenhardt, 2012). In a higher education system, simple rules can be a commitment to a set of graduate attributes, to collaboration and shared practice, to authenticity in assessment, and the role of feedback and transparency in course development processes. The development of these commitments is a dynamic, negotiated process. Organisations frequently identify commitments through strategic planning processes. What distinguishes a self-organising system is the way those commitments are intentionally translated into the structure and normal work of the organisation.

**Embedded Design:** This design principle involves thinking about and acting upon the ways the commitments can be enacted in the organisation's design. It involves developing the systems, tools and strategies that complete a theory based upon an organisation's commitments (Kuhn, 1996). In a higher education setting, this can involve embedding collaborative process in the governance structure, creating tools that assist in sharing feedback, creating a policy about authentic assessment, or articulating processes for embedding graduate attributes in course and subject design processes (Zundans-Fraser & Lancaster, 2012). In all cases, embedded design means making operational those things that the organisation has committed to.

**Similarity at Scale:** Self-organising systems tend to be flatter and less hierarchical than others, although they do possess levels and reflect differential sources of influence in hierarchical ways (Waldrop, 1993). They are distinguished by a similarity at those different levels. In a Higher Education setting, this can mean that the way an executive team functions to approve and monitor the performance of the institutional course profile is focused on the same process and feedback as a faculty team or the team designing and implementing an individual course. This self-similarity is achieved by ensuring that the tools, systems and methods that operationalise the theory are similar at all levels of the organisation. This principle is challenging for higher education organisations that tend to segment leadership and management and operational activity from strategic activity and by level in the organisational hierarchy. In a successful self-organising system, the community “pays attention at scale” meaning that leaders are focused on the same things as those engaged in the day-to-day work in equally dynamic ways.

**Feedback:** According to Pascale et al. (2000), feedback is the way a self-organising system talks to itself. It is the way agency is amplified and the source of dynamic change and adaptation. A system that can feed back and forward as part of a network of constant change among individuals and groups can create emergent change in the organisation. Feedback is termed emergent in Smart Learning (Bain, 2007; Bain & Swan, 2011) because it emerges bottom-up, occurs dynamically not afterwards and as such can help the organisation decide what to do next instead of what happened. In a self-organising system, feedback is gathered about those things the organisation is committed to. In a higher education setting, this could be about the quality of its assessments, or collaborative process, or the extent to which graduate attributes are embedded in the design of courses, etc. Most important, the feedback emerges from the normal work of being a faculty member, leader or student.

**Dispersed Control:** Dispersed control (Holland, 1999) is about empowering those with agency in the system. Shared commitments, feedback and embedded design mean that all have a stake in the way the organisation works. Those doing the actual work of the organisation have pivotal agency in the system. In a higher education setting, an executive team may have a high-level view of the quality of assessment in the university, or the constructive alignment of subjects. That view emerges from the normal work of developing quality assessments and aligning the key features in subject design undertaken by faculty members. The high-level view is an emergent expression of the work and feedback of many who make the quality happen. Smart Learning and Smart Tools makes possible the multi-level view of those things to which the organisation is committed and has embedded in its design.
Dispersed Control is also informed by networks and network theory and the way in which networks of teams can create professional small worlds (Barabási, 2002) that pool collective intelligence, as people work together collaboratively. In Smart Learning, intra and inter-individual capability and organisational culture are engendered by more collaborative organisational design. Culture building extends beyond the development of individuals and leaders to focus on the organisation and the way its processes, methods and systems engender shared agency (Roberston, 2014).

**Schema:** Dispersed control happens when the organisation shares a schema and its agents are able to engage in self-organising behaviour (Gell-Man, 1994). While the initial cornerstones of that schema may not be autogenetic (Kauffman, 1995), the idea of the self-organising university is that those design cornerstones are subject to dynamic and ongoing adaptation and evolution. The schema is dynamic and negotiated and subject to change based upon emergent feedback. The schema provides the form required for shared understandings, the creation of a genuine community of practice, and the flexibility required for individual agency within that community.

When applied to educational settings the principles represent a model for the Design of Adaptive Educational Systems (DoAES). In Smart Learning, the principles provide design guidance for creating a self-organising university. The simple rules make possible the elusive articulation of what the organisation stands for, its big ideas, commitments, and values, while embedded design drives the way those high-level commitments are articulated in the organisation’s design and ultimately its day-to-day work. At CSU commitments drive the design of more articulated role descriptions, new policies, and the Employee Development and Review Scheme. The emergent feedback principle also expresses commitments, beliefs and values about what the organisation stands for. This is evident in the feedback tools embedded in the Smart Tools CourseSpace and WorkSpace, but more expansively in the way feedback expresses agency in the organisation (Bain & Drengenberg, 2014). Feedback is the focus of the way the organisation is governed, what happens at meetings and in the way the organisation problem solves. The focus of feedback is on the things the organisation values - quality learning design, collaboration, and quality learning and teaching.

The dispersed control and similarity at scale principles inform the way the organisation is designed, and specifically the governance structure. This includes the self-similar roles of faculty and university committees and the way control for decision-making, informed by feedback, is dispersed broadly across the community. We see evidence of this at CSU in the new and critical roles of the Library, the Education for Practice Institute, Centre for Indigenous Studies, and Academic Support, as they inform the course design process and provide pivotal feedback for the course approval. Course design is collaborative and inclusive, control is dispersed and there is a self-similar focus on the work of key groups across different levels of the organisation - course team, faculty and University.

Table 1 describes the ways in which the theoretical principles are and have been employed in the Smart Learning initiative.
**Table 1**

*The Theory in Action in Smart Learning*

<table>
<thead>
<tr>
<th>Principle</th>
<th>Example Application</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple rules</td>
<td>Commitments in baseline phase of Smart Tools, development of integrated standards, CSU Graduate Learning Outcomes (GLOs), Tenets of the Course Approval (CAP) and Curriculum Learning and Teaching (CLT) policies</td>
<td>Articulate CSU Strategy in values, set the cornerstone for the design of Learning and Teaching at CSU</td>
</tr>
<tr>
<td>Embedded design</td>
<td>The SL organisational design – Document suite- role descriptions. Course Approval Policy and CLT policy, Academic Governance meeting process structure, Smart Tools CourseSpace, the way Smart Tools requires products and assessment tasks to reflect commitments and integrated standards</td>
<td>Commitments are embedded in all elements of the CSU design. Each echoes the other- all are in each (e.g., collaboration is required in the meeting process, to use the tools, instantiated in the policies, and in the role descriptions). Graduate Learning Outcomes are reflected in commitments, in integrated standards, in role descriptions, in the work process created by the ST CourseSpace and in the feedback expectations</td>
</tr>
<tr>
<td>Emergent feedback</td>
<td>Smart Tools feedback modules, feedback process, multiple rounds, analytics approach scaling up the granular work of course teams to the Institutional level. Feedback focuses on commitments reflected in the policy</td>
<td>Empower the agency of those actively involved in the feedback process. Ensure feedback reflects commitments and the design. Happens as part of the normal work and a time proximal to that work. Ensure that data is aligned with normal work and emerges from that work and is not about what happened</td>
</tr>
<tr>
<td>Self-similarity</td>
<td>Role and function of committee process, collaborative process at all levels of the organisation</td>
<td>Simplify the organisational design and focus on the commitments. The terms of reference of university committees is self-similar to those of faculty committees. Course Directors position descriptions are self-similar to those of Faculty Members and Educational Designers. Their roles (committees and individuals) may vary around responsibility and level of leadership, although they focus on the same self-similar things</td>
</tr>
<tr>
<td>Dispersed control</td>
<td>Course team collaborative decision-making, transparency of feedback processes</td>
<td>Empower the individuals doing the challenging work on the ground to drive the process, provide the critical feedback and drive the expression of commitments in their day-to-day work. Ensure that the governance structure functions bottom-up and focuses on commitments - Simplify Up (Drengenberg, 2013; Latour, 2010)</td>
</tr>
</tbody>
</table>
Each of the examples in the table is represented as discrete entities for ease of understanding. Equally important is the way they interact. Figure 2 shows the Smart Learning Design Process and the way it has been deployed at CSU; beginning with the development of commitments and showing the way each principle is applied to create a schema for learning and teaching.

Figure 2. Smart Learning Design Process

![Smart Learning Design Process Diagram]

A feature of Smart Learning Design is that all of the theoretical concepts can be seen in any element of the design and each in all. For example, Smart Tools reflects the way simple rules about specific research-based practice are embedded in the software, that in turn reflects the way groups and teams function within the Academic Governance process, which in turn reflects the policy and in the way faculty members are recognised and rewarded. Reference to all of these elements - Governance, Policy, Tools can be seen in each of these elements and each in all. This self-similarity results in a dynamic and constantly evolving organisation. The agency of those involved working with a shared schema generates ongoing emergent feedback that produces change in the schema and adaption.
Learning and Teaching Research

The six principles provide a framework for designing an organisation for learning and teaching. Of equal importance is the way research about learning and teaching is configured in that framework. Critical to Smart Learning is answering the “what” questions: What are the simple rules about? What is the university committed to in terms of educational practice? What are the processes, approaches and practices that will be embedded in policies, role descriptions, promotion approach, etc? Smart Learning employs over sixty years of modelling and research related to factors that influence student learning to answer the “what” questions. As such, the content of SL has a broad and deep base in longitudinal international research about learning and teaching that defines the content of the model and interacts with the theoretical principles. Most important, are the connections between theory and research whereby the theory connects with research to drive the design of the Smart Learning approach. The sections that follow provide descriptions of the specific research areas that inform Smart Learning. The model employed to undertake the integration of learning and teaching research in Smart Learning is also described.

Models and Large Scale Analyses of Teaching and Learning

This title refers broadly to work that has sought to identify at a high level those factors that contribute to student learning. It includes the work of Carroll (1963) who focused on the role of perseverance, instructional quality, aptitude and opportunity in the 1960’s. Bloom (1976) examined factors including, instructional quality, affective factors and aptitude. Walberg (1986) examined the role and dimensions of teaching that influence student learning. This also included the role of aptitude, quality of instruction, motivation and environmental factors. More recently, Hattie (2009) undertook a synthesis of over 800 meta-analyses relating to student achievement, identifying those factors that exert more or less of an influence on student learning.

The models and analyses described here and others (e.g., Brophy & Good, 1986; Marzano, 1998; Scheerens, 1992) reflect conclusions drawn from literally thousands of discrete research efforts that make modelling around the aforementioned variables possible. In Smart Learning, these models and analyses serve to map the territory and identify foci that have informed the selection of learning and teaching approaches, the identification of feedback sources and methods and the approach to analytics, the design of software, and the creation of professional development activity and resources. They provide a content focus for the theoretical principles described in the previous section. This includes informing the identification of commitments, the approaches that are embedded in the design of the organisation and in the focus of feedback. Further, those bodies of literature address variables that interact in their contribution to the content of the Smart Learning approach. For example, feedback and assessment are made more or less meaningful depending upon the learning context in which they are placed. Constructive alignment is dependent upon the quality of the elements being aligned. Smart Learning, as a transformational organisational design approach, is a way to create the supportive learning and teaching context required to ensure that the discrete features of feedback or successful teaching practice is likely to be maximised.

Goal Setting Frameworks, Scaffolding, Mapping and Success Criteria

Hattie (2009) describes a range of strategies that improve learning by focusing clearly on learning intention and process. Those approaches include goal setting, mapping and organisers, learning hierarchies, mastery learning, and worked examples. The central idea of this research focuses on the power associated with making clear the goals, process and expected outcomes of learning. These approaches cover a broad range of cognitive and meta-cognitive learning strategies including advance organisation, concept mapping, self-questioning, self-monitoring, and sequencing modeling and practice in worked examples (de Boer, Donker-Bergstra & Kostons 2013; Dignath, Büttner, & Langfeldt, 2007; Hattie, 2009; Hattie, Biggs & Purdie, 1996). These meta-analyses and others incorporate research from thousands of studies that have investigated the discrete elements of learner intention showing that they make a profound and powerful contribution to student learning. They have produced
effect sizes in comparative studies of .41 for advance organisers, .57 for concept mapping, .58 for mastery learning and .56 for goal setting (Hattie, 2009). At the core of the connections made among these different areas of research, is the straightforward idea that articulating intent and learning process creates conditions that are more conducive to successful learning by clarifying expectations and making visible what learners are asked to do. This is especially the case for learners who do not have the background and related meta-cognitive skills required to deconstruct and interpret less intentional learning experiences.

In Smart Learning, the research on learning intention and process is embedded at all levels. For example, at the highest level of course design, the Smart Tools CourseSpace leads users through a process of setting commitments and expectations, identifying and integrating standards and then using the scaffolded functionality of the CourseSpace software, its maps and organisers, to build out a complete course. At a more granular level the Smart Lecture design and delivery tool, in the Smart Tools WorkSpace, includes design functionality that enables users to set goals, identify self-questions, scaffold learning strategy and work through examples. The main idea of making learning intention and experiences clear echoes at different (self-similar) levels from the design of a course to the development of a learning activity. To this end, the design of the tools reflect the research on intention and the application of that research within a theoretical framework. Further, the organisational change dimensions of Smart Learning, including the approach to governance, policy, promotion, performance management are designed to create the context in which the potential of those practices can be amplified. While Hattie (2009) and Marzano (1998) described the immediate learning and teaching conditions required for successful practice, Smart Learning takes up the organisational context required for scalable application in a university setting.

Constructive Alignment

Constructive alignment (Biggs, 1996) can be seen as an extension of the body of work related to learning intention described by Hattie (2009). The concept involves building extant connections between learning intention or expected outcomes, teaching activity/learning experience and assessment in the development of learning experiences. Constructive alignment has a common sense appeal and has garnered significant support in higher education (Biggs & Tang, 2007; Larkin & Richardson, 2013; Teater, 2011). The empirical support for this approach is reflected in its connection to the clarification of learner intent and in additional work that has examined its efficacy as a discrete practice (Kenney, 2012; Treleaven & Voola, 2008). While not as extensive as other areas identified throughout this review (e.g., cooperation or feedback), there is strong support for designing learning and curricular experiences employing this principle. A number of studies have shown improved satisfaction and learning outcomes for courses that applied the principle of constructive alignment (Kuhn & Rundle-Thiele, 2010; Vanfretti & Farrokhabadi, 2013; Wang, Su, Cheung, Wong & Kwong, 2013).

In Smart Learning, constructive alignment is a pivotal feature of the learning design process. Smart Tools operationalises the principle in a series of design steps embedded in the subject development module of the CourseSpace. The software calls upon developers to connect assessment tasks to outcomes and outcomes to learning experiences and then embed those connections in the design of teaching modules. At a higher more metaphorical level, the design of Smart Tools involves the alignment of commitments to needs and drivers and conceptual module in the baseline phase; in the integration of standards in the development of course products (that reflect those standards) and in the development of assessment tasks. The Smart Learning process and the CourseSpace involve a cascading self-similar alignment of design features at different levels of the process. The different levels of use of constructive alignment at course and subject levels, described in the example, also illustrates the self-similarity principle of the theory where the process used to align a subject is self-similar to the process employed to align a course. Constructive alignment can be seen as a mechanism for enacting the theory in practice— a commitment to constructive alignment is embedded in the tools, policy, and feedback in ways that are self-similar across levels of the course and governance process.
Feedback and Assessment

Feedback is a critical factor in predicting student learning. The research on feedback is extensive and has identified the influence of form, timing, type, and source as determinants of feedback effectiveness (Brinko, 1993; Scheeler; Ruhl & McAfee, 2004). Feedback is not a standalone contributor to student learning. Its effectiveness is related to a range of contextual factors related to the broader circumstances under which feedback is shared (Hattie, 2009; Marzano, 1998). The effectiveness of feedback is contingent upon the overall quality of the learning experience—the quality of the assessment task and the compendium of influences related to learning intention and process (Hattie, 2009). Feedback has produced effect sizes ranging from .73 (Hattie, 2009) to 1.13 (Marzano, 1998).

Smart Learning takes up the role of feedback in two ways. First, feedback is placed in a meaningful context as a key component of a self-organising system; feedback is secured within the broader organisational design context where commitments are clear, where embedded design enacts those commitments, where control is dispersed and where feedback can operate in emergent self-similar ways. Second, and as a consequence of the design, feedback is deeply embedded in the work of teams at all levels—those working to develop courses and those at the university level approving courses. An example of this includes the way in which each module of the Smart Tools CourseSpace requires feedback as part of the course design process. Feedback emerges from building commitments, integrating standards, developing assessment tasks, subjects and modules. Course team members share feedback about the way the team has gone about completing these design tasks. In the WorkSpace, feedback is shared as developers build learning activities and students engage with them. In all cases, feedback is an emergent expression of the normal work of individuals and groups. The research on when and how feedback is effective informs the way emergent feedback is structured in Smart Learning. Feedback in Smart Learning comes from multiple sources, focuses on the role of peers and subordinates, encourages immediacy, is evidence-based and positively focused (Brinko, 1993; Hattie, 2009; Marzano, 1998; Scheeler et al., 2004).

In Smart Learning feedback also operates in concert with the other research-based practices and approaches described here in the form of criterion and standards based assessment (CSBA). Criterion and standards based assessment includes a number of the learning intention features described earlier including goal-setting, mapping and scaffolding (Hattie, 2009). Research on, and analysis of, CSBA indicates that its success is contingent upon contextual factors including the provision of exemplars and its integration into the broader instructional milieu (Donovan, Price & Rust, 2001, Sadler, 2005). Smart Learning creates the broader contextual influences necessary for making CSBA effective.

Unique to Smart Learning is the way in which technology, when applied to the normal day-to-day work of a self-organising system, can make feedback emerge from that routine activity and the normal work of the organisation. A study in progress is examining the effects of feedback on teaching at scale in environments using the Edge Technology Tools (described subsequently) (Bain & Weston, in progress). In Smart Learning, feedback is less about what happened and more about what is happening (Bain, 2007).

Teaching Approaches

One of the key findings emerging from the meta-analyses of factors that influence student learning is that there is immense variability in the efficacy of different teaching approaches. For example, lectures and mastery teaching are both forms of teacher led instruction. Lectures have been shown to exert only a limited effect on achievement. Mastery learning (Hunter, 2004) is a powerful source of achievement effects. Similarly, cooperative learning that pays attention to the structure of the experience, individual accountability and interdependence among participants is a powerful predictor of achievement (Hattie, 2009; Johnson, Johnson & Smith, 2014; Marzano, 1998; Slavin, 1996). Group work much less so. Other teaching approaches that have strong student learning effects include peer mediation, reciprocal teaching, and cognitive and meta-cognitive strategies, especially when they are taught explicitly (Rosenshine, 1997).
Smart Learning has selected those approaches that have strong effects on student learning to feature in the Smart Tools WorkSpace. The WorkSpace developer, player and student tools represent the key achievement related features of cooperative learning and explicit instruction including worked examples, modelling, practice, individual accountability and mutual interdependence in the design of learning activity builders and the players. Doing so ensures that those features are represented in both the design and delivery of learning activities. A model of problem-based cooperative learning is included, that captures the strengths of cooperative approaches in a problem-based approach. This design was developed because of the modest findings associated with problem-based learning (Albanese & Mitchell, 1993; Colliver, 2000; Dochy, Segers, Van den Bossche & Gijbels, 2003; Gibjels, Dochy, Van den Bossche, & Segers, 2005). The three approaches currently identified represent a beginning. The research-based approach to identifying teaching approaches creates the conditions for including more pedagogical types in Smart Learning and Smart Tools, while the research-based framework creates the conditions for employing a range of efficacious theories and approaches.
Table 2

**Smart Learning Foundational Research**

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>Role In Smart Learning</th>
<th>Research(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models of learning</td>
<td>Refers to researchers who have modelled the factors that contribute to student learning</td>
<td>These researchers mapped the territory related to factors influencing learning. They provide a broad-brush framework for the foci of Smart Learning especially related to the development of simple rules, analytics framework, and to drive the embedded design process</td>
<td>Bloom (1976); Brophy &amp; Good (1986); Carroll (1963); Hattie (2009); Scheerens (1992); Walberg (1986)</td>
</tr>
<tr>
<td>Goal setting frameworks, scaffolding and mapping</td>
<td>Research on creating an extant process for goal setting, scaffolding and framing at all levels of the organisation and in all activities</td>
<td>This work provides the basis for the design of the Smart Tools CourseSpace and the context for learning design in Smart Learning</td>
<td>de Boer, Donker-Bergstra &amp; Kostons (2013); Dignath, Buttner &amp; Langfeldt (2007); Hattie (2009); Hattie, Biggs &amp; Purdie (1996)</td>
</tr>
<tr>
<td>Constructive alignment</td>
<td>A widely accepted design principle to make learning more accessible</td>
<td>Applied in SL to course and subject design including the content of Smart Tools modules</td>
<td>Biggs &amp; Tang (2007, 2011); Kenney (2012); Larkin &amp; Richardson (2013); Teater (2011); Treleaven &amp; Voola (2008)</td>
</tr>
<tr>
<td>Teaching approaches</td>
<td>These are approaches that have been shown to improve student learning. This is an ongoing process employed to seek out those approaches that when reconciled with content and technology can leverage the CSU learning and teaching value proposition</td>
<td>Embedded in the design of WorkSpace tools including feedback processes and the CLT policy and Implementation process</td>
<td>Hattie (2009); Johnson, Maruyama, Johnson, Nelson &amp; Skon (1981); Kyndt et al. (2013); Rosenshine (1986, 2012); Slavin (1996); Springer, Stanne &amp; Donovan (1999)</td>
</tr>
</tbody>
</table>

\(^2\) The research described here constitutes a sample of the extensive work in these areas.
The practices described here are deployed within the organisational design that emerges from the theoretical framework. The interaction of the theoretical principles creates the conditions for the interaction of the practices embedded in Smart Learning. The tools, the policies, the organisational process are each and all designed to situate successful practice in an organisational design where those practices can interact and contribute successfully to student learning. For example, a collaborative organisational process where meetings function successfully to pool the capacity of participants or tools that make feedback about effective practice possible creates a context for solving problems about the use of a teaching approach. Collaborative process and research-based pedagogy interact. As was the case with the theory, the practices in Smart Learning are designed to interact with each other because the organisational design makes that interaction possible.

**Efficacy Research Underpinning Smart Learning**

As with any theory, the central question about its utility is whether it works in relation to the problem or challenge it seeks to explain or resolve. The research on the application of the self-organising design principles to education has occurred over a 22-year period and continues through Smart Learning.

**The Self-Organising Schools Project**

The cornerstone of the body of work underpinning Smart Learning is a 12-year comprehensive research-practitioner study that established and tested the principles described in Table 1 in the re-design of a secondary education setting (Bain, 2007) entitled the “Self-Organising School (SOS) Project.” The Central Question for the Self-Organising School project was: Could a complex educational organisation employ the design principles to reform its design and learning and teaching processes in ways that were more responsive to students’ learning needs and resulted in better teaching, learning and achievement at scale? The central question served as a guide for the development of more specific sub-questions related to the integrity of implementation of the design, effects on student learning, levels of collaborative practice, and the use of technology. Table 3 summarises the program of research and specific questions asked in the Self-Organising Schools Project and the results of empirical study.
### Table 3

**Smart Learning Efficacy Research Self-Organising School Project**

<table>
<thead>
<tr>
<th>Question/Area</th>
<th>Study</th>
<th>Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the SOS theory and design principles result in an altered model of school</td>
<td>Bain (2007, 2010); Bain (in progress); Weston &amp; Brookes (2008)</td>
<td>Five year longitudinal case study involving dependent measures of</td>
<td>Successful implementation of the design based upon the SOS principles as evidenced by change in pedagogical practice and high levels of implementation integrity of that practice, sustained over five years and triangulated with teacher, team, student, and management surveys perspective. High levels of implementation integrity over five years indicating sustainability of the design</td>
</tr>
<tr>
<td>design and was it implemented with integrity?</td>
<td></td>
<td>over 1,600, 55 minute classroom observations, triangulated with</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>over 1,300 teacher, management and team surveys and 12,000 student</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>evaluations</td>
<td></td>
</tr>
<tr>
<td>Did the design create a Collaborative Process and Culture?</td>
<td>Bain &amp; Hess (2002)</td>
<td>Comparison Cohort design study, based upon SOS school pre and during</td>
<td>Positive reports of collaborative culture at higher levels than pre-change in the target school and than the data from comparison schools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the theory– based change process. Dependent measure - survey data</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>gathered in situ and compared with data derived from 42 other like</td>
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<tr>
<td></td>
<td></td>
<td>schools (aggregated on the same survey)</td>
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</tr>
<tr>
<td>Did improvement in Student Achievement co-vary with the introduction of the</td>
<td>Bain &amp; Ross (1999)</td>
<td>A longitudinal cohort design to compare SAT-1 performance for</td>
<td>92 point improvement in SAT-1 performance differential (p=.0003) in favour of the students who participated in the change. Also, established gains for students with a learning disability</td>
</tr>
<tr>
<td>design?</td>
<td></td>
<td>160 students prior to the change process with those who had participated in the theory-based change. Entry profiles used as a covariate comparison indicated no significant difference at entry</td>
<td></td>
</tr>
<tr>
<td>Question/Area</td>
<td>Study</td>
<td>Method</td>
<td>Result</td>
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</tr>
<tr>
<td>What was the practice fidelity of the SOS project?</td>
<td>Bain (2011)</td>
<td>Regression analysis of four years of formal observations of classroom teaching practice (criterion variable) with the perspectives of administrators, teachers, and teaching peers about the reform’s implementation to ascertain the practice fidelity of the SOS</td>
<td>The results showed sustained levels of practice fidelity and statistically significant differences in the ratings of administrators, teachers and peers, although those differences reduced overall as the reform progressed</td>
</tr>
<tr>
<td>Application of the theoretical principles to planned change in Hong Kong</td>
<td>Bain, Walker &amp; Chan (2011)</td>
<td>Descriptive case study employed to illustrate the SOS principles and discuss their role in site-based capacity building</td>
<td>Describes the way the principles were taken up in a high achieving secondary school setting</td>
</tr>
<tr>
<td>Use of the theoretical principles to determine the practice fidelity of a program for gifted students in a Canadian elementary school</td>
<td>Boyd (2012)</td>
<td>Mixed methods case study approach</td>
<td>Showed a moderate to high-level of practice fidelity related to the quality of implementation of the program</td>
</tr>
</tbody>
</table>
When viewed together, the studies both qualitative and quantitative indicate that the SOS design principles did influence the school design, were able to exert an influence on the quality of teaching and learning in the self-organising school in sustainable ways. This included demonstrable improvement in student achievement, the quality of teaching, levels of collaboration and collaborative culture, and the use of technology described subsequently. Further, the application of the approach in primary and secondary school settings suggest its utility both as a design metaphor and an evaluative heuristic for determining practice fidelity.

From School to University

A key question often asked about Smart Learning pertains to its trajectory from the initial work in schools to its application to learning and teaching in higher education settings. This body of research began in 2003 and is continuing. It involved applying the principles to the design of graduate level courses in inclusive education as a way to address the concerns about higher education course design identified earlier in this report. The cornerstone of that effort is a recently completed study by Zundans-Fraser (2014), describing the application of the six theoretical principles to the design of a higher education course. The study described a design-based research approach to the challenges faced by CSU in course design and articulated a process to respond to those challenges using the theoretical principles described here. This initial work has expanded to include studies of the effects of the design approach on professional schema development (Auhl, in progress) student learning, self-efficacy and pattern language (Bain, Lancaster, Zundans & Parkes, 2009; Bain & Zundans, 2009; Lancaster & Bain, 2010; Zundans-Fraser & Lancaster, 2012), in situ teaching to practice of graduate teachers (Lancaster, in progress), and in the theory to practice work of graduate teachers (Grima-Farrell, 2012).
<table>
<thead>
<tr>
<th>Question/Area</th>
<th>Study</th>
<th>Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicability of the design principles to higher education. Can the approach be employed purposefully to guide a course design process?</td>
<td>Zundans-Fraser (2014)</td>
<td>Eight-year longitudinal case study employing design-based research approach. Measures include semi-structured interviews, researcher’s log and observational notes, document analysis</td>
<td>Validated that the key issues identified in the literature were present in the study setting. Demonstrated that the principles could be employed as a design metaphor in HE course design. Showed the process using design-based research as a response to the issues. High levels of satisfaction expressed by the design team, stakeholders and students</td>
</tr>
<tr>
<td>Schema development as reflected in pattern language acquisition</td>
<td>Bain, Lancaster &amp; Zundans (2009)</td>
<td>Uninterrupted time series design with 54 volunteer preservice teacher educators. Dependent measure – use of pattern language</td>
<td>Improvement in frequency and quality of student pattern language use covaried with the application of the embedded design principle in the subject learning experience</td>
</tr>
<tr>
<td>Schema Development</td>
<td>Auhl (in progress)</td>
<td>Longitudinal comparison group design examining the ways in which schema development co-varied with the type of preparation program. Dependent measure schema development</td>
<td>Schema for professional practice was most developed in a program designed using the SOS principles</td>
</tr>
<tr>
<td>Student achievement in subject designed employing the embedded design principle</td>
<td>Bain, Lancaster, Zundans &amp; Parkes (2009)</td>
<td>Repeated Measures counterbalanced design with 90 volunteer pre-service educators employing an achievement quiz</td>
<td>Mastery level knowledge covaried with the application of the embedded design principle</td>
</tr>
<tr>
<td>Question/Area</td>
<td>Study</td>
<td>Method</td>
<td>Result</td>
</tr>
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</tr>
<tr>
<td>Effect of the design on self-efficacy</td>
<td>Lancaster &amp; Bain (2010)</td>
<td>Comparison group design involving 36 pre-service educators using self-efficacy measure (SEIPD)</td>
<td>Statistically significant improvement in student achievement for both conditions- one involving applied experience, the other embedded design</td>
</tr>
<tr>
<td>Effect of subject design on performance in workplace learning setting</td>
<td>Lancaster (in progress)</td>
<td>Comparison group design using direct observation of teacher led instruction using an observational scale</td>
<td>Students who experienced the embedded design approach taught more effectively in situ during a practicum experience</td>
</tr>
<tr>
<td>The use of embedded design to enhance student self-efficacy</td>
<td>Zundans-Fraser &amp; Lancaster (2012)</td>
<td>Comparison group design involving 41 pre-service educators using self-efficacy measure (SEIPD)</td>
<td>A theoretically designed subject significantly improved self-efficacy between pre and post occasions</td>
</tr>
<tr>
<td>Research to Practice</td>
<td>Grima-Farrell (2012)</td>
<td>Comparative case study mixed methods design employing surveys, focus groups and permanent product records</td>
<td>Linked course design to research to practice capability of graduate educators</td>
</tr>
</tbody>
</table>
The studies described here lend empirical support to Smart Learning as an effective higher education curriculum design methodology that responds to the key areas of need identified in the literature. The results also echo the findings of the original Self-Organising School Project showing that the design approach, improves achievement, teaching outcomes, student disposition, schema development and the translation of research to practice. Further, the work of Zundans-Fraser (2014) provides a methodological framework for the use of the theory in a higher education setting.

**Edge Technology**

Edge Technology (Bain & Weston, 2012) is a model for developing technologies that improve the quality of learning and teaching and align with the Design of Adaptive Educational Systems approach described here. To be an Edge Technology, an innovation must extend the capacity of a teacher or learner by extending the human-machine relationship in ways that complement their learning and teaching abilities. This can take the form of a teacher designing and differentiating learning experiences for multiple groups of students with differentiated content and pedagogy in ways that reduces cognitive load, maintains cohesion and a manageable learning environment. Edge Technologies also heighten collaboration and flatten communication hierarchies in educational contexts by creating the conditions for more effective collaboration and more efficient exchange of learning and teaching information (Bain & Weston, 2012). They shorten the cognitive distance between those involved in the joint educational enterprise of designing and delivering learning experiences. This can involve a team of university educators integrating content, pedagogy and technology in a real-time collaboration that includes collaborative design and emergent feedback. In this way Edge Technologies can be seen as vehicles to catalyse dispersed control in a self-organising system, as they make possible a shortening of cognitive distance to create a collaborative small worlds focus. If an Edge Technology can extend cognition, in doing so it should also build capacity. Users in educational contexts should learn more about design and the integration of pedagogy, content and the creation of learning experiences as a result of common use. Edge Technologies provide a technological representation of the schema that emerges from the application of the DoAES model.

The model for creating Edge Technologies is described by Bain & Swan (2011), and Bain & Weston (2012), and includes using research to map solutions, component design and integration. Edge Technology emerged from a series of studies and descriptive reports undertaken over the last 14 years that examine the tools built using the Edge approach and the behavior of users and the effects of that use (see Table 5). They include work about enabling classroom participation, the examination of gender effects, curriculum design and use, and student and teacher effects. A major focus of this research was a large scale evaluation of the model in the Outcomes Project, a three million dollar research and design initiative that studied the uptake of the tools and their impact on teaching across three school districts in two US states (Weston & Bain, 2014).

**Smart Tools**

In Smart Learning at CSU, the Edge Technology approach is expressed by Smart Tools - a course design, delivery and analytics system for higher education. The tools enable comprehensive course design and delivery from mapping graduate attributes and standards through building and delivering assessment tasks and subjects all the way to the development of an accreditation submission. They make possible a migration from documenting the University course development process to a genuine curriculum design paradigm focused on creating high-quality learning experiences. Smart Tools is comprised of three components:

1. The CourseSpace for course design.
2. The Learning and Teaching WorkSpace- tools for building quality learning activities and generating real-time feedback on their effectiveness. The WorkSpace includes- student facing tools and build collaboration and maximise effective student engagement with the course, the subject and learning experience.
3. Learning and Teaching Analytics- a comprehensive emergent feedback system that scales from classroom or online learning experiences all the way up to university learning and teaching performance.

The CourseSpace is a transparent collaborative course design platform that extends cognitive capability by mapping for multiple levels and domains, which are key variables in higher education curriculum development. Users come to know the product of their design efforts, their courses and subjects through engagement with the software. The CourseSpace engages those involved in a shared design enterprise that makes the product of their thinking about mapping, assessment design and feedback transparent and collaborative. That which is in large measure individually constructed private practice becomes a shared enterprise that pools expertise and intelligence. The Smart Tools WorkSpace makes a research-based learning design approach accessible to educators who may not have an extensive educational background. It reduces the cognitive load associated with the design and delivery of quality instruction and shortens the cognitive distance between teachers and learners and course developers and teachers.

In combination, the Smart Tools components create a technology for higher education that is analogous to those that have exerted transformational effects in other fields like business, medicine and engineering. In those fields, technology has been deployed in a manner that is deeply integrated with their core activities or transactions. When technology enables, empowers, and accelerates a profession’s core transactions, the distinctions between computers and professional practice evaporate. For instance, when a surgeon uses an arthroscope to trim a cartilage, a structural engineer uses computer-assisted design software to simulate the stresses on a bridge, or a sales manager uses customer-relations-management software to predict future inventory needs they do not think about technology. Each one thinks about her or his professional transaction and builds capacity while using the tools (Weston & Bain, 2010). No equivalents of these deep and proximal technologically enabled transactions exist within the prevailing educational paradigm of higher education. Smart Tools is designed to generate this equivalency by assisting members of the CSU community to do the professional work of learning and teaching.
Table 5

Edge Technology Research

<table>
<thead>
<tr>
<th>Question/Area</th>
<th>Study</th>
<th>Method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender effects in a 1:1 technology environment</td>
<td>Bain, Berelowitz, Hess &amp; Jones (2000)</td>
<td>Ex-post-facto comparison group design comparing technology immersion program to a control</td>
<td>Discusses the effect of participation in a high computer-to-student access ratio on female student performance, and reports statistically significant skill increases for male and female students in the high access immersion (embedded design) program</td>
</tr>
<tr>
<td>Initial test of Edge Technology principles focused on embedding research-based practice in Information and Communication Technology (ICT) Tool design</td>
<td>Bain, Huss &amp; Kwong (2000)</td>
<td>Alternating treatments design, involving use of a hypertext discussion tool to augment research-based teaching</td>
<td>Statistically significant improvement in student achievement when technology employed to augment research-based teaching (p=.003)</td>
</tr>
<tr>
<td>Description of curriculum authoring tools</td>
<td>Bain &amp; Huss (2000)</td>
<td>Descriptive article describing antecedent application of Edge Technology</td>
<td>Tools employed to build over 2000 hours of differentiated curriculum</td>
</tr>
<tr>
<td>Does use of the curriculum authoring tools change practice</td>
<td>Bain &amp; Parkes (2006a)</td>
<td>Comparison group design- high and lower level technology users to establish whether higher quality teaching practice covaried with use of a suite of curriculum design tools</td>
<td>Teachers who made higher level use of the technology taught more successfully at statistically significant levels (p=.02) using the teaching approaches that were part of the SOS design</td>
</tr>
<tr>
<td>Do models of knowledge management work in education?</td>
<td>Bain &amp; Parkes (2006b)</td>
<td>Describes issues related to the type and use of data for analytic purposes in education</td>
<td>A foundation of the case for emergent feedback. Introduced concept of proximal and distal data that is a factor in the emergent feedback approach</td>
</tr>
<tr>
<td>Question/Area</td>
<td>Study</td>
<td>Method</td>
<td>Result</td>
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<tr>
<td>To what extent was technology used more or less effectively in settings identified as leaders in the use of ICT?</td>
<td>Weston &amp; Brookes (2008)</td>
<td>Comparative case study of four leading US settings (including the Self-Organising School) identified for the innovative use of technology. Gathered data by survey, interview and school records analysis</td>
<td>More effective technology use at scale in the SOS school than all others, deeper faculty understanding and capacity</td>
</tr>
<tr>
<td>What is the design metaphor for developing emergent feedback tools?</td>
<td>Bain &amp; Swan (2011)</td>
<td>Descriptive article showing the Edge Technology design approach for developing emergent feedback tools</td>
<td>Process used to develop tools employed in the Self-Organising School project</td>
</tr>
<tr>
<td>What is Edge Technology?</td>
<td>Bain &amp; Weston (2012)</td>
<td>A book describing the Edge approach to technology use in schools</td>
<td>The Edge approach explained in detail with examples</td>
</tr>
<tr>
<td>Effectiveness of Edge Technology tools to improve the quality of teaching</td>
<td>Weston &amp; Bain (2014)</td>
<td>Matched-comparison, repeated-measure for intact groups design of the mediating effect of a suite of software on the quality of classroom instruction provided to students by teachers. The quality of instruction provided by teachers in the treatment and control groups was documented via observations that were conducted by an independent research team at pre, mid and post intervals of a 225-day study period</td>
<td>No statistically significant differences at pre-test between treatment and control groups. Over three occasions, no statistically significant differences were found for the control group. Statistically significant differences were found for the overall treatment group at mid and post intervals. Moreover, overall differences between the control and treatment groups were statistically significant at mid and post treatment including a post treatment effect size of 1.54. These results suggest that improving instructional quality could be addressed by information and communications technology effectively mediating research and practice</td>
</tr>
<tr>
<td>Role and effectiveness of feedback at scale when organisations use Edge Technology</td>
<td>Bain &amp; Weston (in progress)</td>
<td>Matched-comparison, repeated-measure for intact groups design of the effect of type, quality and amount of feedback on the quality of instruction by teachers</td>
<td>Preliminary findings show feedback quality and type co-varied with teaching quality at scale</td>
</tr>
</tbody>
</table>
Learning Analytics

The intersection of learning and teaching research, Edge Technology, and emergent feedback creates the conditions for a transformative approach to learning analytics. This approach was described at the recent CSU Learning Analytics Symposium (Bain & Drengenberg, 2014). In Smart Learning, analytics becomes an emergent expression of normal work, part of the agency of those involved in the organisation and what they do day-to-day; what members of the community do with and about the well-researched practice described in this report. The features of that practice are embedded in emergent feedback tools that are used as part of normal work. This stands in contrast to the existing model which is challenged to find relevant data and connect that data with its learning and teaching source. In the learning analytics literature, this connection is termed the middle space (Knight, Buckingham-Shum & Littleton, 2014). From a Smart Learning perspective, feedback is part of the totality of agency in the organisation and inseparable from other activity. Emergent feedback is not part of a sequence or space in a linear sense, nor does it make a traditional temporal distinction among data gathering, analysis and reportage.

Issues associated with surveillance, time-delayed ex-post facto feedback, data utility and ethics that are common in critiques of existing analytics approaches (Slade & Prinsloo, 2013) are addressed in Smart Learning because those involved in the creation and use of feedback are actively engaged with it all of the time. They create it, engage with it, understand it, and use it routinely. No one is surveilled, nor is their behaviour subject to ex post facto reportage.

A second major issue in the learning analytics field pertains to what to measure. Most efforts are not informed by the learning and teaching efficacy research described in this report. Data is often gathered on user behaviour including navigation patterns, downloads, tweet analysis, and pageloads that have not been shown to influence learning. Smart Learning, informed by known relationships and efficacy research in learning and teaching, takes up those factors that influence learning in the design of its emergent feedback model. Feedback helps the community and individuals to decide what to do next over what happened (Bain, 2007). Most important, the learning and teaching potential realised by Smart Tools is an expression of the way theory and research are reconciled in an organisational design that reflects the application of each of the six design principles.

Summary

This body of work, conducted over two decades, has established a trajectory from the literature on theories of self-organisation to the development of a set of design principles subsequently applied to organisational design in education. The design is also informed by over sixty years of efficacy research in learning and teaching that has been applied to those principles. Theory, learning and teaching research, efficacy research and higher education course design sets the foundation for the transformational redesign of a university. Figure 3 describes the research trajectory.
Four important considerations need to be emphasised in concluding this review. First, Smart Learning is a transformative approach focused on change at a scale capable of addressing the challenges faced by CSU and identified in the literature. Its focus is on the things that need to happen to design and deliver better learning and teaching to CSU students at scale. In doing so, it makes extant connections among theory, research, design and practice. Second, the foundation of the model is expansive. The approach is underpinned by extensive, well-accepted longitudinal research about learning and teaching that sits at the heart of the design. The account of theory, learning, teaching and efficacy research provides a clear rationale for, and line of sight to, an organisational design for CSU that is unprecedented in the field. This is especially the case when the challenges facing universities and the magnitude of the change and curricular problems we face are interrogated and understood. Third, understanding Smart Learning is about examining the connections in practice, looking at the detailed relationships among policies, tools, governance processes and roles. The design is an emergent expression of the theory and research described here. It can be “simplified up” (Drengenberg, 2013), although most important is the way the contents of this review are connected to the actual known practice of Smart Learning at CSU. Fourth, the Smart Learning initiative creates the conditions to extend the research described here by investigating the effects of SL at scale. The continuation of a robust research agenda can evolve the model and instantiate CSU’s position as a thought to practice leader in higher education.
References


Bain, A., & Weston, M. E. (2011). *A software mediated approach to improve the quality of teaching using school-wide feedback.* Unpublished manuscript, Charles Sturt University, Bathurst, Australia


