

Teaching Innovation to Strengthen Knowledge Creation in a Digital World

Carolien van den Berg

University of the Western Cape, Cape Town, South Africa

cvandenber@uwc.ac.za

10.34190/EJKM.17.02.004

Abstract: The aim of this paper is to demonstrate design principles for a teaching and learning environment that will strengthen the ability of students to become competent digital innovators. The impact of digital transformation on business and society is palpable, forcing organisations to become more responsive, agile, creative and innovative. Moreover, competitiveness is determined by the ability to apply new knowledge to facilitate innovation through the use of digital technologies. A two-year research study was conducted at a university in South Africa to develop a framework for digital innovation skills. The data were analysed in a four-phase design-based research study that applied mixed-methods research. The research has important implications for the design of a learning environment that facilitates knowledge creation in a digital world.

Keywords: Future skills, Digital innovation, New world of work, Authentic learning, Life-long learning, 21st-century skills, Higher education institutions

1. Introduction

The interactivity and pervasiveness of digital technologies are changing the discourse on the importance of knowledge creation and innovation for organisational success (O Riordan, 2013). Within the digital economy, organisations require a culture that encourages continuous business model innovation enabled by digital technology (Amit and Zott, 2012). The digital future demands a new type of employee who is able to work in unstructured and unpredictable circumstances that are often complex and involve constant change.

Furthermore, demographic changes will result in an ageing workforce and it will become necessary to continuously update skills in all careers via relevant training opportunities to facilitate lifelong learning (Redecker, et al., 2011).

University students need to be prepared for this expanding, interconnected world through the design of a participative, digitally enabled, collaborative learning environment. Higher education institutions (HEIs) are therefore forced to experiment with new formats and strategies for learning and teaching to be able to offer relevant, effective, innovative and high-quality learning experiences (Alexander, et al., 2019). Educators in HEIs need to have the skills to manage and teach digital technologies and, more importantly, to assist their students to become capable of collaborating, solving problems and being creative in the use of digital technologies. A move beyond the current horizons of knowledge and skills within a specific discipline is required in order to be adaptable in the future (Laurillard, 2012).

In the light of these considerations, this paper provides an empirical contribution in the form of a teaching and learning framework to teach digital innovation skills. The framework will help address the discrepancies in competencies being developed in formal education versus the requirements of industry in a digital world.

The paper proceeds as follows. First, the literature reviews the new world of work within the digital economy, and the skills sets required. This is followed by a discussion of the design of the learning environment to enable the development of digital skills. Second, the method used to empirically verify the draft design principles is presented. Next, the research results are presented and discussed, prior to the conclusion of the full study. The outcome of this study is design principles for a teaching and learning environment in HEIs that will enable the cultivation of digital innovation skills to support knowledge creation in a constantly changing world.

2. Skills for the New World of Work

Digitisation requires a more flexible workforce with the ability to change and adapt within a complex global economic environment. This requires an innovative and entrepreneurial spirit, combined with an agile mindset of lifelong learning (Philbeck, Davis and Engtoft Larsen, 2018). Thus, what is required is skills sets to easily

transfer from one type of job to another by being responsive to unexpected circumstances, and to un-learn and re-learn quickly. To be adaptable, individuals will require a combination of certain cognitive (critical thinking, problem-solving) and socio-emotional skills (curiosity, creativity) (Djankov, et al., 2019). Thus, a workforce proficient in new technologies is important, but the skills sets that equate to “human skills such as creativity, originality and initiative, critical thinking, persuasion, and negotiation will likewise retain or increase their value” ... “emotional intelligence, leadership and social influence will, however, increase in prominence” (World Economic Forum [WEF], 2018, p.12). This requires tertiary systems that are more flexible, more successful at producing transferrable higher-order skills, and more able to actively facilitate innovation (Djankov, et al., 2019).

The importance of collaboration among individuals, organisations and even industries is another requirement for future business that is strongly emphasised in the literature. Collaboration gives rise to the sharing of ideas, innovation, and the ability to make changes faster. The requirement for collaborative knowledge exchange between colleagues and peers, and between older and younger, experienced and inexperienced workers, needs to be foregrounded in order to drive experimentation and rapid iteration (Manyika, et al., 2017).

Hierarchies need to be broken down and collaboration platforms need to be created to share information. A digital workplace requires flexibility to work anywhere and anytime using any device, with a focus on work outputs.

Digital transformation poses opportunities for economic growth and social progress, yet depends on reform in education and training, labour market policies, business skills development, and existing social contracts (WEF, 2018). The review of the changing employment landscape emphasises the importance of advanced cognitive skills (such as complex problem-solving), socio-emotional skills (collaboration, team work), and skill combinations that are predictive of adaptability (resilience and the ability to cope with change) (Djankov, et al., 2019; Phillips, et al., 2018).

The umbrella term used to describe the type of skills that students will need to develop in the digital economy is “21st-century skills” (21st CS). A number of frameworks have been developed to define 21st CS, and studies by Dede (2010), Kereluik, et al. (2013), Adamson and Hammond (2014) and P21- Partnership for 21st CS (2019) compared different frameworks to define the primary skills required. In this review, the necessary skills that are predominant for digital innovation were explored, and the framework of Kereluik, et al. (2013) was deemed to be the most comprehensive. This framework consists of foundational, meta- and human knowledge, as illustrated below.

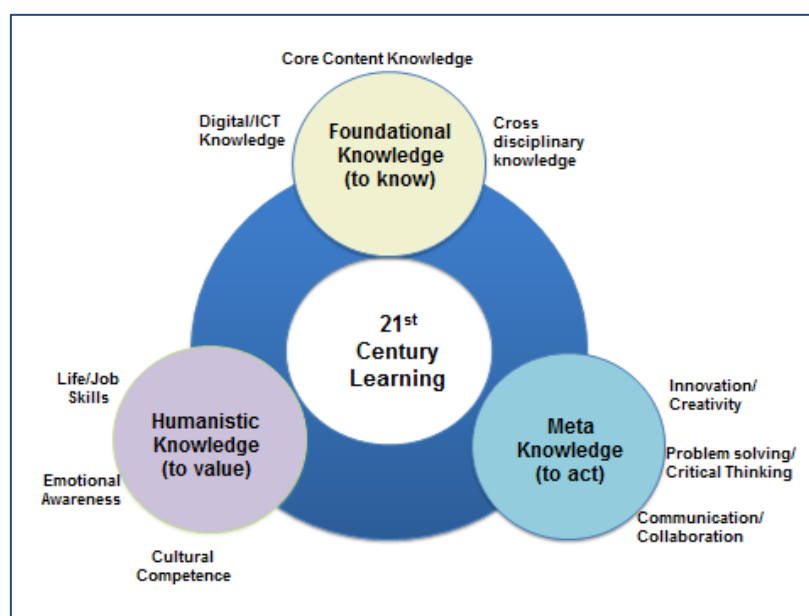


Figure 1: Synthesis of 15 different 21st-century learning frameworks in one visual image (Kereluik, et al., 2013)

As seen in Figure 1, foundational knowledge consists of core content, cross-disciplinary knowledge and digital knowledge. Meta-knowledge is knowledge “to act” using creativity, innovation, problem-solving, critical thinking, communication and collaboration. In the framework, human knowledge includes job and life skills, emotional intelligence and cultural awareness.

3. Teaching Innovation

As discussed above, the diffusion of digital technology is opening up opportunities to innovate (implementation of ideas), and innovation is increasingly being regarded as the skill that separates students who are prepared for the challenges of increased complexity in the digital world from those who are not (P21, 2019). Furthermore, individual innovativeness is no longer viewed as a trait, and studies have proven that it can be learned via effective training in innovation skills (Celuch, Bourdeau and Smothers, 2014).

In the process of learning to innovate, students need to be prepared to think creatively, work creatively with others, learn to implement innovations, reason effectively, use systems thinking, make judgements and decisions, solve problems, communicate clearly, and collaborate with others (P21, 2019). Using a simpler description, one might say that innovation skills cover three basic areas: thinking (customer-focused thinking and problem-solving), telling (getting others on board and storytelling), and doing (learning through experimentation). Cobo (2013) explores this further by identifying the elements necessary for an innovative society and stresses the criticality of developing skills for innovation in education. These include:

- The shift from what we learn to how we learn to better understand how knowledge is co-created and re-constructed. Furthermore, the ability to filter information to develop the skills to think scientifically.
- The fluctuating relationship between digital technologies and content to assist students in how to think, and not to tell them what to think.
- Education needs to be participative and to utilise technology that digitally enables collaboration.
- The changing conceptions of space-time and the emphasis on lifelong learning. These aspects talk to what Castells (2004, p.36) terms “timeless time”, shaped by the “space of flows”. In the digital economy, work becomes much more flexible and unstable, transforming space and time.
- The development of soft skills or social behavioural skills, such as those depicted in Figure 1.

Higher education institutions need to prepare graduates for an evolving job market that promotes a culture of entrepreneurial thinking and innovation. Pedagogies that foster hands-on, real-world experiences for learners, where they become partners in learning inventions, and knowledge creation are required (Becker, et al., 2018). Such activities are a key element of authentic learning, are active and experiential, and provide learners with many of the skills they need when they enter the world of work. The principles of authentic learning, as outlined in Herrington, Reeves and Oliver (2010), are:

- Provide authentic contexts that reflect the way the knowledge will be used in real life.
- Provide authentic task/s that have real-world relevance, are ill defined, continue over an extended period and are integrated across subject areas.
- Provide access to expert performances and the modelling of processes by allowing students access to experts within the industry, collaboration with other students and facilitation by the lecturer.
- Provide multiple roles and perspectives to move away from a linear method of instruction.
- Support the collaborative construction of knowledge tasks.
- Promote reflection to enable abstractions to be formed by students whilst they are working within the authentic context and completing authentic tasks.
- Promote articulation to enable tacit knowledge to be made explicit.
- Provide coaching and scaffolding by the teacher at critical times to support students in their learning.
- Provide for integrated assessment of learning within the tasks to provide the opportunity for students to demonstrate their acquired knowledge as the learning progresses until the final product is delivered.

The review of the new world of work provided context for the skills requirements in a digital world and this, in turn, informed the design of a potential learning environment. The next step in the study was to test the incorporation of draft design principles into the learning environment.

4. Methodology

A design-based research (DBR) study was undertaken to develop design principles that can be applied in higher education settings to aid students in the development of capabilities for a digital world. The goal was to apply a methodology that will not only evaluate the effectiveness of the educational interventions, but also provide design guidelines for implementing such interventions (Herrington, Reeves and Oliver, 2010). In DBR, the researcher collaborates with participants and other stakeholders to improve teaching and learning practices in an interactive, systematic, flexible and iterative way within real-world settings (Herrington and Reeves, 2011). A four-phased DBR approach was applied, as depicted in Figure 2.

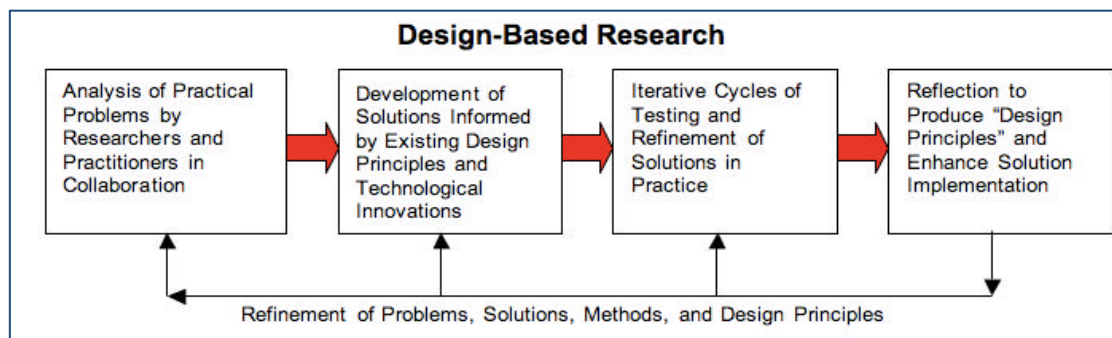


Figure 2: Predictive and design-based research approaches in educational technology research (Reeves, 2006)

The first phase commences with a review of the literature and interaction with different stakeholders in order to base the initial design (phase 2) on sound theoretical principles. In the iterative cycles (phase 3), the theory is enriched and updated based on the data collected in each cycle and the experiences of the designers (Herrington and Reeves, 2011).

Following this approach, the study commenced with a review of the new world of work in order to provide context for the skills requirements in a digital world. This provided context for the design of draft principles for a learning environment that will enable knowledge creation. The draft principles developed during the second phase are depicted in Table 1.

Drawing on the draft principles, a course was designed in which students were required to partner with industry and manage projects within teams to implement a digital innovation in the client's business. An overview of the content development for and assessment of the first iteration is depicted in Table 2.

Table 1: Draft design principles

Draft design principle	Requirements	Skills sets required by principle
Encourage collaboration	Students need to perform tasks in teams. Ensure that students collaborate to solve problems in class and in projects. Use peer reviews.	Collaboration and communication Digital/ICT knowledge
Have students produce real products for a real audience	Require students to do a team-based project with organisations within their community and where they are required to implement a real solution. Work within a specific industry that needs assistance with digital innovation.	Problem-solving and critical thinking Life/job skills Emotional intelligence (EQ) and ethics
Allow students to find their own solutions within an authentic context	Encourage innovation by letting students take their own initiative. Do not put too much structure in place, use some scaffolding when required.	Creativity and innovation

Draft design principle	Requirements	Skills sets required by principle
		Problem-solving and critical thinking
Implement exercises that encourage reflection	Design learning tasks that will enable students to reflect on their learning, for example via a blog. Provide guidelines via rubrics on content to be included in the blogs, such as weekly reflections on what has been learned, what they enjoyed and what they did not enjoy.	Digital/ICT skills Life/job skills
Allow for mistakes	Innovation requires the willingness to fail. A course needs to be designed in which students are encouraged to try different approaches and, when something fails, they need to try another approach without being penalised for it.	Creativity and innovation Problem-solving and critical thinking
Apply project-based learning to combine inquiry with accountability	Involve students in projects that are based on real-world, authentic problems that are meaningful and engaging.	Cross-disciplinary skills Collaboration and communication Life/job skills

Table 2: Content development focused on digital innovation, iteration 1

Subject	Assessments and requirements
Effective communication Agile project management (Scrum)	
Digital innovation The business model canvas	Pre-reading and podcast on learning management system (LMS) and Google Drive Individual questionnaire 1 in Google Forms Lateral thinking quiz in class
Team presentations	Team presentation of current business model and digital innovation idea
The lean start-up Scrum versus lean The worker of the future	Pre-reading and podcast on LMS and Google Drive Individual blog 1
Team presentations	Project initiation document and presentation
Peer review feedback presentation Team progress and plans	Peer review report Individual blog 2
Quiz Team progress and plans The future of work	Pre-reading and podcast on LMS and Google Drive
Team progress and plans Individual presentation Final team presentation and project report	Teams present their current status and receive feedback from lecturer and other teams Individual blog 3 Individual presentation via a digital/photo story

During the third phase of the DBR study, the draft design principles were tested and refined in three iterations over a period of two years.

4.1 Data collection

Design-based research supports the collection of qualitative and/or quantitative data in cycles of several weeks, semesters or years. This study used multiple data sources to ensure that evidence on the success of the design principles was collected from multiple angles.

During each iteration, data was collected from a student survey and from student blogs. Students were asked to fill in a survey on Google Forms at the start of the semester to test their perceptions prior to the course (Survey 1), and again at the end of the course to test their perceptions on the outcome of the course (Survey 2). The survey questions were adapted from the Student Success Toolkit (George, 2015) using a five-point Likert scale. The knowledge tested in the survey stems from the framework by Kereluik, et al. (2013), as illustrated in Figure 1.

The results provided the students' perceptions of their capability development throughout the semester. All survey and reflection responses were transferred from Google to Excel spreadsheets. Students had the option of participating in the survey, with no consequences if they selected the option not to participate. An example of the survey can be viewed at <https://forms.gle/xpUdD7pp65Aibz1p6>

Students were further required to subscribe to a blog and submit three blogs during the semester. They could use any open source blog site such as WordPress. The blog posts were used as a space where they could reflect on their own progress during the semester, and they were also encouraged to share their experiences with other students, who could give feedback to them. The blog posts also included additional aspects, such as a personal inventory of their own strengths, weaknesses, opportunities and threats, emotional intelligence, personality and values. They were also asked to reflect on their journey in the first few years once they left the university, and what they wanted to achieve in the future. For an example of a student blog, see <https://keanu341.wordpress.com/>

The first iteration was with a group of 43 students registered for a postgraduate course in Information Systems (IS). The second iteration took place with a group of 40 third-year IS students during the second semester of 2016, and the third iteration took place with 40 third-year IS students during the second semester of 2017. The study obtained ethics clearance from the university's Research Committee prior to the commencement of the research.

4.2 Data analysis

Data analysis applied a mixed-methods approach to test the skills sets acquired by the students via a regression analysis and thereafter through a qualitative analysis of the student blogs. The regression analysis determined the relationships among nine variables (Figure 1) obtained in the survey results, and applied student assessment scores as the dependent variable. The analysis tested the reliance on certain skills during an initial assessment and again at the end of the course.

The analysis helped to identify the skills that were statistically significant using the p-value to test the null hypothesis. The null hypothesis estimated that all slope coefficients equal zero, with the alternative hypothesis projecting at least one of the slope coefficients not equal to zero. The hypothesis was rejected if at least one of the independent variables explained the value of the dependent variable by reviewing the p-value. If a variable has a low p-value (< 0.05), it indicates that the null hypothesis can be rejected and the variable therefore is a meaningful addition to the framework (Horton and Fitzmaurice, 2004).

The findings from the blogs were analysed to identify the themes, which were coded according to the nine skills sets (Figure 1). The first letter of the students' names and the first letter of their surnames were used as pseudonyms to record the student answers, and a number was added to indicate the iteration. The researcher was actively involved in the data gathering in order to keep the data as close as possible to the actual events. The steps prescribed by Miles and Huberman (1994) with which to systematically organise the data were applied in the qualitative data analysis. These steps are the following:

- Reflecting on the data, organising and finding emerging patterns.
- Coding data in relation to the skills sets and sorting into potential themes.
- Applying an iterative approach, as prescribed in the DBR approach, which enables the researcher to develop a deeper understanding of the phenomenon as richer concepts emerged.

All datasets were analysed to look for patterns and similarities in the responses to ensure that they represented the views of the entire group.

5. Results

5.1 Quantitative analysis

As described above, students completed two surveys – one at the start of the course and one at the end to test their perceived development during the semester. The findings from the regression analysis to test the students' skills development across the three iterations are illustrated in Table 3.

Table 3: Regression results

Knowledge creation		Iteration 1: P-value		Iteration 2: P-value		Iteration 3: P-value	
		Pre	Post	Pre	Post	Pre	Post
Foundation	Core content	0.034	0.764	0.325	0.054	0.387	0.048
	Digital / ICT	0.231	0.701	0.756	0.747	0.179	0.614
	Cross-disciplinary	0.050	0.407	0.003	0.591	0.011	0.330
Meta	Communication / collaboration	0.320	0.898	0.410	0.385	0.334	0.939
	Problem-solving / critical thinking	0.351	0.706	0.814	0.317	0.037	0.009
	Innovation / creativity	0.117	0.047	0.803	0.051	0.001	0.0004
Human	Life / job skills	0.493	0.516	0.040	0.230	0.430	0.001
	Emotional intelligence	0.152	0.626	0.792	0.452	0.224	0.173
	Cultural competence	0.437	0.811	0.639	0.414	0.227	0.004

Highlighted areas: p-value (< 0.05)

The values that stand out in the first and second survey are highlighted to indicate the skills that were statistically significant. This indicates that the students had an accurate perception of knowledge creation in the assessment pertaining to those skills, and furthermore that those skills were being assessed.

Foundational knowledge, as depicted in Figure 1, consists of core content, digital/ICT and cross-disciplinary knowledge. Core content knowledge, coupled with academic achievement, is frequently cited as an essential skill in the 21st century (Kereluik, et al., 2013). The content required to teach digital business innovation, as shown in Table 2, was analysed during the different iterations to test the validity thereof. Digital and ICT knowledge include, for example:

- New media literacy to critically assess and develop content that uses new media forms, and to leverage these media for persuasive communication,
- Cognitive load management, or the ability to discriminate and filter information by importance and to understand how to maximise cognitive functioning using a variety of tools and techniques, and
- Virtual collaboration, to work productively, to drive engagement and to demonstrate presence as a member of a virtual team (Davies, Devin and Gorbis, 2011).

Cross-disciplinary knowledge integrates information across different fields or domains, thus the need for the ability to understand, organise and connect vast amounts of information (Kereluik, et al., 2013).

Course design enabled students to apply the core content knowledge to a practical project, and to create tasks and assessments that facilitate the application of cross-disciplinary knowledge that they had obtained within the broader framework of their overall studies. Students need to be able to track changes in technology and to be familiar with the applications of new technology within a business environment. As such, students had to develop a digital innovation using a variety of potential technological solutions within an organisation.

In a review of the results from the regression analysis, foundational knowledge pertaining to core content and cross-disciplinary knowledge showed the most significance at the onset of the three iterations. When the survey was completed at the end of the semester, core content showed a statistical significance in iteration two and three. This is an improvement on the first iteration, because core content was still a significant skill in the final assessment. Interventions were undertaken after the first iteration to introduce design thinking. By following a design-thinking approach, students became involved in a process of collaboratively solving complex, real-world or wicked problems. A further advantage of this approach is the strong focus on collaboration and teamwork, as well as the cultivation of empathy and social interaction within the rollout of the design process (Koh, et al., 2015). Design thinking provided students with a much clearer idea in terms of the stages and rollout of their capstone projects.

Meta-knowledge is knowledge needed “to act” using creativity, innovation, problem-solving, critical thinking, communication and collaboration. This is the process of working with foundational knowledge.

Creativity and innovation can be encouraged via a wide range of ideation exercises, such as brainstorming. Students had to create a number of new ideas that could be useful, and then follow a process of analysing and refining the ideas to those that are appropriate for the client’s business.

The students collaborated to develop, implement and communicate new ideas within teams and to share these with other teams. It is important to encourage students to be open and responsive to new and diverse perspectives and to incorporate input and feedback. Assessments had to be designed to facilitate this process and to reward originality and inventiveness in work, whilst simultaneously testing for the feasibility of the project to make a tangible and useful contribution to the business partners. Mistakes during the process had to be accommodated, because failure is an opportunity to learn. Creativity and innovation are often a long-term, cyclical process of small successes and frequent mistakes (P21, 2019).

Problem-solving and critical thinking can be interpreted as the ability to make informed decisions based on information to resolve a specific problem or to achieve a specific end goal (Kereluik, et al., 2013). In order to achieve this, students had to be able to analyse and evaluate evidence, understand alternative points of view and make connections between information and arguments. Conclusions had to be drawn based on the best analysis, and students were required to reflect critically on learning experiences and processes.

Communication and collaboration can be seen as the ability to clearly express oneself via oral, written, nonverbal and digital means, and to interact respectfully with diverse audiences. Collaboration further requires flexibility, willingness to participate, and recognition of group and individual efforts and success (Kereluik, et al., 2013). In order to develop these skills in students, authentic tasks and assessments were developed to demonstrate that these skills had been acquired.

The results show that students had an accurate perception of the requirement for creativity and innovation in the final assessment using their core content knowledge. The fact that more skills sets did not show a statistically significant outcome during the first two iterations points to the fact that the course design required refinement. In the first two iterations, students could select their own partners from a particular industry, i.e. creative industries. In the third iteration, students were allocated to entrepreneurs within start-ups who were selected from a business incubator. Students felt more empowered to work within the start-up environment because there was less of a hierarchy within the organisations and the student teams were seen as valuable contributors.

Human knowledge includes life and career skills, emotional and ethical awareness, and cultural awareness.

Life and career skills encompass aspects such as flexibility and adaptability to change in terms of different roles, jobs or responsibilities. Students need to develop initiative and self-direction in order to function in a climate of ambiguity. As discussed, the future world of work requires a commitment to lifelong learning.

Emotional and ethical awareness requires individuals to be able to imagine themselves in someone else’s position and to engage in ethical decision-making (Kereluik, et al., 2013). In the future world of work, individuals will require the ability to form a deep understanding of human emotions and to be able to interact

successfully with other humans. In this world of work, autonomy, machine learning, artificial intelligence, etc. will become part of daily life, stressing the importance of interpersonal skills.

Cultural competencies expand with effective communication and collaboration to include an appreciation of the ideas and emotions of all types of individuals (Kereluik, et al., 2013). The diversity of the South African cultural landscape, coupled with the impact of globalisation on the workforce, requires these competencies in our future workforce.

The results obtained for the perceived development of human knowledge showed a significant improvement in the third iteration. This can be attributed to changes in the choice of industry partners and to more explicit instruction in EQ and ethics in the course. To improve the development of human knowledge, students were required to do personality tests and EQ tests and write about the findings in their blogs.

5.2 Qualitative analysis of student reflections

The reflections from the student blogs were analysed to validate the findings from the quantitative data as they pertain to skills development. From each student's blog, evidence of their personal reflections was organised according to foundational knowledge, meta-knowledge and human knowledge (Figure 1). This occurred during each iteration to assist in identifying the areas that needed to be improved upon. The findings are summarised in the sections below, and illustrated by extracts from student blogs.

5.2.1 Foundational knowledge

The incorporation of design thinking to assist teams with the development of innovations in collaboration with industry partners from the second iteration was cited by students as very beneficial, as it assisted with the retention of their core content knowledge. One of the students had the following to say about the value of design thinking during the second iteration:

What really interested me was the design thinking process to help me understand the content. It made me look at how to be creative or incorporate creativity when thinking about things from a business and IT perspective. It showed me how [to] address problems from a new point of view and be more liberal when it came to finding solutions to problems. (FA2)

Cross-disciplinary knowledge is a requirement for all study areas in which one wants to future-proof the curriculum. The development thereof was facilitated via group work and interaction with industry partners from the onset of the course. As depicted in Table 3, these skills sets were drawn on from the start of the course. A quote about the students' experience regarding this engagement highlights this:

I have always worked in groups, but the group work we did in this course was different to what I'm used to, it was much more practical and it reflected the work environment more than the usual group work we did. I think this is because this time we actually worked with a real business, which gave us a real professional feel. (AS3)

Findings from the quantitative analysis did not show a significant improvement in ICT/digital skills. Although the students were required to develop blogs using an online platform, other aspects, such as the use of wikis, digital stories and similar assessments that require digital techniques, can also be incorporated into the design.

For example, students can be tasked with creating their own websites for their blogs and encouraged to use graphics, video clips and other multimedia. However, working in a team and being tasked to develop a system exposed the students to more advanced digital and ICT knowledge, as comments from some students show:

I had no prior technical experience when developing an actual system, just theoretical knowledge; the main assignment has helped me to develop some programming and developing skills with regard to a system. (SM1)

What I enjoy more is that we are doing practical work, which prepares us for life after this course; the tasks done in this course help us to be more creative/ innovative and help us to gain some technical skills that will work to our advantage in the workplace. (ND2)

During the assignment preparation I have grown interested in programming. After learning that our group could not provide an application for our client, I have started looking at many ways to develop an application and I am in the process of learning about HTML. (KM3)

5.1.2 Meta-knowledge

An analysis of the quantitative data pointed to discrepancies in the perceived development of communication and collaboration skills, as there was no statistically significant improvement over the three iterations. From a review of the feedback, it can be surmised that a big factor that contributed to this was the expectations of students of working as a team. This was a big learning curve for many students, as the following extracts show:

I must first say it has not been a very easy road because I had to work with people I did not know who have different personalities and attitudes. However, I have learned a lot during this project about myself it showed my strongest character as I need to be able to handle different issues and working under pressure. I am very thankful of the knowledge I have received in this project as I will use it for future endorsement and apply it on the actual working environment. (NW2)

By doing this assignment I have learnt the importance of teamwork and being a team player. As team members we had to improvise and put aside any personal agendas especially those that would sabotage the success of this project. Being in a group and working as a group, I believe it prepares us for the working or the corporate world. It is essential that we are aware of each other's strengths and weaknesses and be able to accommodate each other. (DM3)

The cultivation of creativity and innovation was stimulated via the encouragement of students to experiment with different solutions and to present the findings to their facilitator and peers. Teams received feedback on their progress and were encouraged to change, update, and start brainstorming again if required. An environment needs to be created in which student teams are encouraged to experiment, make mistakes and learn in order to cultivate creativity. Findings from the quantitative analysis pointed out that this area showed a statistically significant improvement across the three iterations. In an analysis of the student blogs it was also cited by students as an important factor in their perceived skills development:

Personally this course has taken me out of my comfort zone and taught me how to think creatively, as well as that no idea is a stupid idea. During one of the teachings in the lectures, our lecturer said that "Think of any idea and put it in a sticky note, it does not matter what it is just put it in a sticky note and stick it to the board" it was amazing to know that whatever idea that one has in class won't be posed as a stupid idea. This is one of the reasons that I enjoy and find this module interesting. (AB2)

I enjoyed that we had to think outside the box and had no limitations when brainstorming. The solutions to the company's problem had to bring value to the business but also consider the capacity we have as full-time students. A final solution or conclusion was reached by funnelling all the ideas. (TT3)

Opportunities need to be provided for students to find their own solutions, as this learning environment encourages students to solve problems using a variety of resources. The students were unfamiliar with this type of learning and needed some coaching to immerse them in the projects. In the third iteration, different industry partners were chosen and this proved to be beneficial to students in the development of their critical thinking and problem-solving skills. One of the students said the following:

What I enjoy the most and interest me the most is that the course challenges me to think out of the box and to constantly find new solutions to problems that some organisations are facing on an operational level. (BM3)

5.1.3 Human knowledge

During the first two iterations, the cultivation of human knowledge was problematic, specifically for the development of emotional intelligence (EQ) and cultural skills. An intervention undertaken was to include more exercises to build awareness and to partner students with entrepreneurs within start-ups to cultivate life and job skills. During the final iteration, learners were made aware of EQ, and time was spent during one

lecture to conduct a test and discuss individual findings. Learners were further encouraged to do another on-line assessment and to report the findings in their reflective blogs.

I think knowing your type of emotional intelligence or the way in which you handle situations can go a long way in finding what you need to improve about yourself, how you approach others and how you justify your actions. It is important to have an understanding about yourself for peace of mind and to enable you to find your life purpose or life path. (MB3)

During the third iteration, a more focused approach was followed to make the learners aware of their social imprint, and the choice of industry partners further facilitated the process. Time was also devoted during lecture hours to give instruction on the importance of listening and empathising, as highlighted by students in their blogs.

I learned or acquired interpersonal skills in the sense that in class for example we have different people of all races and ethnicity. In order to have a comfortable learning environment, I had to understand, view and feel how the next person was thinking, and how to handle conflict especially. That is in new skill I can say is a game changer for me. (SZ3)

I acquired the skill to listen to what the next person has to say and actually view things from someone's perspective and ideology. This has improved my life drastically as I now am able to actually take in criticism without taking offence to what was said. (MM3)

As described above, the analysis of data during the third phase of this DBR study resulted in a process of testing and refining the design principles. After the third iteration, the draft design principles were updated according to the results. The results show the positive impact on student learning and the growth of an innovative culture amongst the students who participated in the courses during the three iterations.

6. Phase 4: Updated Design Principles

Once the learning design had been implemented and refined within iterative cycles, the final phase of the DBR study was to reflect on the process and to produce principles that can be applied for future development and implementation decisions (Herrington, et al., 2010).

The design principles need to contribute to the existing knowledge base to provide other practitioners with practical guidelines for implementation in similar interventions. The principles need to further assist future research to address complex educational problems. The draft design principles created in the second phase, as depicted in Table 1, were refined and updated during the three iterations, resulting in the updated design principles depicted in the Table 4.

Table 4: Updated design principles

Principle 1	Ensure collaboration takes place
Requirements	Student teams should be selected prior to the commencement of the course, and selection from different disciplines per group is recommended. Facilitation by the lecturer during lectures to review and encourage participation by individual members, and to monitor potential conflict in teams. Allow teams to resolve their own conflicts and provide some scaffolding where required. Only intervene and mediate when the situation becomes untenable. Use a blended learning environment to encourage online collaboration, as well as face-to-face collaboration. Assessments need to include the monitoring of collaboration by team members, along with their overall work ethic.
Update	The requirements were refined from those described for the initial draft design principle.
Principle 2	Create a learning environment that encourages adaptability and flexibility by encouraging experimentation

Requirements	Innovation requires the participants to be willing to fail and to try other options. Encourage this via formative assessment of the tasks that culminate in the capstone project. Focus on the process followed and not on the initial outcomes, to allow students to learn from mistakes and refine the final product. Apply design thinking to encourage ideation, and brainstorming to allow learners to become more accustomed to experiment and change course if required. Assessments should actively involve feedback mechanisms in the rubrics to increase student motivation and active involvement. Apply multi-modal pedagogies to allow for free design to take place. Both the lecturer and the students need to learn to embrace the uncertainties and open-ended nature of design problems, and to learn to accept failure. The lecturer should stress the importance of productive failure and assist students to correct prototypes and encourage them to try new things and new ways of doing.
Update	The principle was moved from the fifth principle in the draft design to the second principle. The initial draft principle was, "Allow for mistakes to happen". This was updated to better describe the principle and to replace "mistake" with "experimentation". The requirements were also refined to better describe the learning interventions.
Principle 3	Implement a formal process of reflection
Requirements	Students should be given the option to do this via a blog or via a website or vlog. Provide guidelines via rubrics on content to be included in the reflections, such as weekly discussions on what has been learned, and what was good, bad and ugly. Include exercises to make students more comfortable with innovation and experimentation via creative expression. For example, allow them to reflect on futurist scenarios and find solutions for issues focused on equality, sustainability, social justice and ethics. Include tasks in which students need to reflect on the challenges that technological and environmental transformations are posing for their own future. Lecturer and peers must provide formative feedback to the students on their reflections during the semester, and the formal assessment of all reflections (blogs) should occur at the end of the semester.
Update	The principle was changed from "Implement exercises that encourage reflection" to "Implement a formal process of reflection". This made the principle more tangible and ingrained it in the course design. The requirements were also updated to reflect this change and to provide better guidance in terms of the implementation thereof.
Principle 4	Enable the development of ethical awareness
Requirements	Make students aware of their effect on society and take them through the process of design thinking, where they start with user needs and combine user stories with empathy maps and/or personas. They need to become aware of the wider imprint that they have on society, as well as that the user can be human or nonhuman, along with the systemic implications thereof. They then have to follow the processes of prototyping and testing, and repeating the process where required. Students need exposure to their overall impact on the design process with industry partners, so as to consider ethical implications such as justice, equity, privacy, autonomy, safety and security, sustainability and wellbeing, amongst others.
Update	This principle was added when it became evident that humanistic knowledge was not adequately developed within the course design. The third iteration included more exercises on EQ and ethics, and it was after this iteration that the principle was added to the final design.
Principle 5	Implement integrated, authentic assessments
Requirements	Teams should be involved in a capstone project that is rolled out over the course of a semester. The project should consist of multiple tasks that build onto one another.

	Student teams must present their progress with their projects on a regular basis during class. Feedback must be provided per presentation to point out possible pitfalls and to afford students the opportunity to update accordingly. Peers should also be involved in the feedback process to open up the conversation and to allow an environment of mutual learning and sharing. Feedback that is substantive and informative should be provided, rather than feedback that is comparative or competitive. Feedback should be provided that models how to incorporate evaluation, including identifying patterns of errors and wrong answers, into positive strategies for future success.
Update	This principle was added to combine the second and third draft design principles in Table 1. These principles were too vague and did not contain stringent requirements for the design of the learning environment.
Principle 6	Apply project-based learning to combine inquiry with accountability
Requirements	Require learners to do a team-based project with organisations within their community during which they are required to implement a real solution/polished product. The project ought to be broken down into a number of tasks that culminate in the finished project. Learners get formative feedback during this process to enable them to rework solutions and create a more polished product. Encourage a focus on social awareness. Have a strong emphasis on ethical business practices. Partner with entrepreneurs, preferably with start-ups, to encourage mutual, collaborative problem-solving and learning.
Update	The requirements were updated to provide more guidance and direction for the design of a learning environment that will facilitate knowledge creation.

7. Conclusion

This paper explored the complexities that a digital world of work poses to knowledge workers. The need to anticipate trends and prepare for future skills requirements to prepare university learners for this uncertain future was emphasised.

To address the misalignment between what is taught in formal education versus what is required in an innovative, digital world, the paper reviewed the evolution of employment. Thereafter, the potential knowledge frameworks to achieve 21st-century learning were analysed. The skills sets that were explored include core content knowledge, digital skills, cross-disciplinary skills, communication, collaboration, problem-solving, critical thinking, innovation, creativity, life and job skills, emotional intelligence and cultural competence.

The teaching and learning environment needed to enable digital innovation skills to support knowledge creation was explored, and the application of an authentic learning environment was foregrounded. The study developed draft design principles that were tested and refined over a period of two years in three iterations.

The paper concludes with recommended design principles for a teaching and learning environment that will enable the cultivation of innovation skills to strengthen knowledge creation in a digital world.

References

- Becker, S.A., Brown, M., Dahlstrom, E., Davis, A., DePaul, K., Diaz, V. and Pomerantz, J., 2018. *Horizon report: 2018 Higher Education Edition*. Louisville, CO: EDUCAUSE.
- Adamson, F., & Darling-Hammond, L. (2015). Policy pathways for twenty-first century skills. In P. Griffin & E. Care (Eds.), *Assessment and teaching of 21st century skills: Methods and approach* (pp. 293–310). Dordrecht: Springer.
- Alexander, B., Ashford-Rowe, K., Barajas-Murph, N., Dobbin, G., Knott, J., McCormack, M., Pomerantz, J., Seilhamer, R. and Weber, N., 2019. *EDUCAUSE Horizon Report 2019 Higher Education Edition* (pp. 3-41). EDU19.
- Amit, R. and Zott, C., 2012. Creating value through business model innovation. *MIT Sloan Management Review*, 53(3), pp.41-49.
- Castells, M., 2004. *Network society*. Northampton, MA: Edward Elgar Publishing Ltd.

- Celuch, K., Bourdeau, B. and Smothers, J., 2014. Thinking innovatively about teaching innovation and ideation: Getting students to think differently. *Journal of Research in Innovative Teaching*, 7(1), pp.27-36.
- Cobo, C. 2013. Skills for innovation: Envisioning an education that prepares for the changing world. *Curriculum Journal*, 24(1), pp.67-85.
- Davies, A., Fidler, D. and Gorbis, M., 2011. Future work skills 2020. *Institute for the Future for University of Phoenix Research Institute*, 540.
- Dede, C., 2010. Comparing frameworks for 21st century skills. In: J. Bellanca and R. Brandt, eds. *21st Century skills: Rethinking how students learn*. Bloomington: Solution Tree Press. pp.51-76.
- Djankov, S., Saliola, F., Chen, R., Connon, D. and Cusolito, A., 2019. *World Development Report 2019: The Changing Nature of Work : Main Report (Chinese)*. Washington, D.C.: World Bank Group.
- George, D., 2015. *Student success kit guide* [online] Available at: <studylib.net/doc/9717312/student-success-kit-student-guide> [Accessed 7 September 2015].
- Herrington, J. and Reeves, T.C., 2011. Using design principles to improve pedagogical practice and promote student engagement. In: *ASCILITE 2011 - The Australasian Society for Computers in Learning in Tertiary Education*. Hobart, Tasmania, 4-7 December 2011. pp.594-601.
- Herrington, J., Reeves, T.C. and Oliver, R., 2010. A guide to authentic e-learning. *British Journal of Educational Technology*, 42, pp.167-184.
- Horton, N.J. and Fitzmaurice, G.M., 2004. Regression analysis of multiple source and multiple informant data from complex survey samples. *Statistics in Medicine*, 23(18), pp.2911-2933.
- Kereluik, K., Mishra, P., Fahnoe, C. and Terry, L., 2013. What knowledge is of most worth. *Journal of Digital Learning in Teacher Education*, 29(4), pp.127-140.
- Koh, J.H.L., Chai, C.S., Wong, B. and Hong, H.-Y., 2015. *Design thinking for education*. Singapore: Springer.
- Laurillard, D., 2012. *Teaching as a design science*. New York: Routledge Taylor and Francis Group.
- Manyika, J., Chui, M., Miremadi, M., Bughin, J., George, K., Willmott, P. and Dewhurst, M., 2017. *A future that works: Automation, employment and productivity*. McKinsey Global Institute, 2017.
- Miles, M. and Huberman, A., 1994. *Qualitative data analysis: An expanded sourcebook*. 2nd ed. Thousand Oaks, CA: Sage.
- O Riordan, N., 2013, December. Knowledge creation: hidden driver of innovation in the digital era. In *International Conference on Information Systems (ICIS) 2013: Reshaping Society Through Information Systems Design, Milan, Italy, 15-18 December 2013*.
- Partnership for 21st Century Skills (P21). 2019. Framework for 21st century learning. Retrieved from <http://www.battelleforkids.org/networks/p21/frameworks-resources> [Accessed 5/6/2019].
- Philbeck, T., Davis, N. and Engtoft Larsen, A.M., 2018. *Values, ethics and innovation: Rethinking technological development in the Fourth Industrial Revolution*. Geneva, Switzerland [online] Available at: <http://www3.weforum.org/docs/WEF_WP_Values_Ethics_Innovation_2018.pdf> [Accessed 15/2/2019].
- Phillips, R., Seedat, Y. and Van der Westhuizen, S., 2018. *Creating South Africa's future workforce*. Johannesburg: Accenture Consulting Research.
- Redecker, C., Leis, M., Leendertse, M., Punie, Y., Gijsbers, G., Kirschner, P., Stoyanov, S. and Hoogveld, B., 2011. *The future of learning: Preparing for change*. Luxembourg: Office of the European Union.
- Reeves, T.C., 2006. Design research from a technology perspective. In: J. van den Akker, K. Gravemeijer, S. McKenney and N. Nieveen, eds. *Educational design research*. London: Routledge. pp.52-66.
- World Economic Forum (WEF), 2018. *The Future of Jobs Report 2018*. Geneva, Switzerland: WEF.