A Strategy for Promoting the use of Collective Intelligence within a Technology Education Context: A Case Study

Vasilije Kokotovich
University of Technology, Sydney
Ruth Thompson
Bossely Park High School

Abstract

This paper examines and provides a critical analysis of the results of a recent research project/study. This study will show how Australian students in remote and rural locations collaborated on a set of negotiated design projects with partner schools in city locations. We argue the activity of pooling/sharing divergent perspectives and heuristics [collective intelligence] is a powerful educational tool. This study will posit that a central way teachers/academics may help students to identify design issues/problems and formulate ways to address them is by taking advantage of and using collective intelligence in a classroom context. Cooperative learning and collaborative problem solving are effective in improving academic and social skills. Often it is difficult for students, operating in the context of technology education, to experience collaborative design in the same manner as globalised corporations which develop products for distribution around the world. As aspects of the design process become more and more globally distributed, it is increasingly important for technology education students to have the ability to engage with meaningful problems and achieve desirable solutions that parallel and mimic the real world. Further, this paper investigated the strengths, weaknesses, and merits of providing school students with an understanding of the real world experience of collaborative on-line designing 24 hour rapid prototyping and remote realisation and manufacture. The research to be discussed led us to develop a strategy for moving technology education forward towards providing rich learning experiences that develop in students, the abilities to more fully engage in a truly collaborative design process. It is argued this study potentially has wider implications beyond technology education.

Introduction

The central focus of this paper is to present and discuss beneficial issues surrounding the development of collective intelligence and collaborative education strategies using the vehicle of state of the art rapid prototyping technologies in a secondary school context. In most design and technology classrooms the existing technology education resources date back to the mid-20th Century. The schools involved in this project have enhanced their design and technology education resource base through the introduction of 21st Century, rapid prototyping technology more commonly found in the workplace. Although designers and some design teams work in isolation, with the growth of global corporations sometimes the sun never sets on a design. That is to say as one team calls it a day, they pass their hard work onto another team in a different time zone. This suggests the global corporations take advantage of the notion of collective intelligence both within teams, and between design teams. In addition, they take advantage of modern technologies such as internet communications and rapid prototyping facilities. More often than not these methods have significantly decreased the time it takes for modern corporations to move from an understanding of a product need, to a strategic business decision to develop a product and then subsequently design and prototype the product ideas. As the notion of using collective intelligence is seen as a powerful design tool and part of a powerful and effective design process, this project used these design tools as part of the design process.

In general with respect to technology education, more specifically Design and Technology and Engineering subjects, a core theme resonating through both tertiary and secondary educational institutions centres on a desire to relate student experiences to the 'real world'. However, far too often these experiences are limited to discussions and activities that are less than representational of the real world. Frequently, the learning experiences in which the students engage require them to individually develop their problem solving abilities and design ideas. Conversely, in the industrial commercial world design and technology problems are often resolved by groups of people working in a synergistic way, in order to develop solutions to problems presented to a group of individuals, or groups of individuals. This activity draws upon the individual knowledge bases, creative abilities, and shared understanding / identification of the problems constituent parts. While we understand, historically the term "collective intelligence" has a variety of meanings in a variety of contexts in various domains, for the purposes of this study we take it to mean that individuals operating as a synergistic whole are by definition developing a 'collective intelligence'. Further, we argue that this activity assists individuals to self actualise their personal problem solving abilities. Consequently, if students are given the opportunities to work with students in remote and rural locations to collaborate in a negotiated design project with partner schools in city locations and to work towards the solution of a design challenge which is rapid prototyped and delivered in much the same manner as Australia's manufacturing industry currently performs for Daimler Benz and Toyota, we would move their technology education experiences towards those encountered in the industrial commercial world.

The Initial Stage of the Study

This project drew together and number of partner organisations in order to develop a coherent set of projects aimed towards shaping the technology education learning experiences of secondary school students in distinctly different parts of Australia. These partner organisations included various high schools, Universities, and industrial commercial partners [i.e. IBM Australia,REA,IIATE,PTC]. In order to develop the working relationships between the partner organisations a general conference made up of representatives from the partner organisations was held. This initial meeting enabled the project to move into the next phase, that is the implementation of the projects in the classroom. Teachers were thoroughly briefed on the projected path of the project and were able to give voice to any concerns they had and have these explained in the context of the project. Drafts of the design problems for the technology education students were prepared and presented to the delegates for discussion and modification. Teachers were also able to shape the projects to suit their needs within the broad aims of this study, thus enabling them to have more ownership of the Design projects that had been set.

The telecommunications facilities were setup and practiced. These facilities were set up under the guidance of the REA [ReEngineering Australia] programme, in that individual schools were granted access to a WEBEX Portal. This set-up schools for telecommunications that provided on-line collaboration functionality for the partner schools. This activity broadened teacher understanding about conferencing and communicating across the internet. This further enabled discussions surrounding rapid prototyping and manufacturing giving them a better understanding of leading edge practices in industry. It also gave them greater insight into the value of using 3D parametric modelling software to design and draw objects. The teacher leaders present were provided opportunities to see leading edge technologies associated with the Rapid prototyping industry first hand. In addition, PTC set up and demonstrated ProjectLink – collaborative software for the teacher associates to use when critiquing design solutions.

As a result of the conference the representatives from the partner schools, after vigorous discussion, collaboratively agreed that there would be one individual practice project and three main collaborative design projects given to the various student cohorts. Further, it was determined this would occur in a measured and progressive manner.

The Methodology of the Study

In order to progressively develop and encourage the use of collective intelligence within various cohorts of students, it was necessary for the representatives from the partner schools to outline and structure the design projects for the students. In terms of student involvement with respect to the various divergent cohorts of students, discussion revealed that School project leaders were not unduly concerned about where the students were drawn from. It was decided that a mix of senior and juniors was not detrimental to the project. Clarification was made regarding the preference for the same students following the whole project through to completion (with the rider that if this was not possible then so be it). Further, with respect to Age /Year groupings the design projects/challenges should be taught to the level of the students involved within each school, and was to be entirely at the discretion of the classroom teacher. To assist the classroom teachers, student mentors were made available and drawn from education and design faculties from ACU {Australian Catholic University}, Griffith University and UTS {University of technology, Sydney}. It was felt that the mentors should endeavour to visit their school as many times as possible or at least once. While the numbers in this study varied somewhat, in general throughout all projects/challenges, 152-172 students were involved and fully engaged. Additionally, 8-10 classroom teachers and 12-13 student mentors participated.

Number of times they are going to contact the students and the manner in which they would contact students was both Face to face and On-line. The online aspect of mentoring them, via Webex, was a telecommunications system for online meetings. Project leaders in each institution had an account and managed this. Windchill Project Link is an industry standard collaborative tool to pass the project around between students and mentors. This also saves the iterations of projects so these can be used as work samples for the website.

Preliminary Project

It was determined an introductory project should develop various important communication skill sets prior to any major collaborative work. These skill sets would require the students to do some preliminary sketches on paper, develop some preliminary drawings in a CAD package and find where they could determine the VOLUME of the part. A decision was made that all students involved in the project will draw a key tag and export the STL and send it via the internet to the manufacturing centre [located within

Bossley Park high school in NSW Australia] were they would also assist the students by providing feedback on design ideas if this is required. Additionally, these key tags were printed to test the system. A specification sheet was uploaded to the web. Each student as an individual was to design an object that can attach to a 25 diameter key ring for the purpose of identifying a set of keys in a pocket. The key tags were modelled at the production centre in class lots. That is to say that the products need not be linked to each other in any way. Student sketches were received and uploaded to the webpage. Students have designed and drawn key tags in various 3D software packages including Pro/Desktop, Pro/Engineer, and Solidworks. Work samples from each challenge were uploaded to the project website, and it should be noted this preliminary project had no assessment criteria other than the key tag being a functional acrylic item.

The goal of this preliminary project was to enable students and staff to develop a small product that had the capacity to quickly move through the process of drawing in CAD model- Exporting "stl" files - emailing to the manufacturing centre - being 3D printed and posting back to the product developer. These activities and experiences would develop, within each student, the appropriate skill sets and a general understanding of operating as a part of a distributed collaborative network, paralleling the industrial commercial world.

Project One

Once the various diverse cohorts of students from around Australia completed the 'Key tag' project, each practicing their skill sets, the subsequent and first major collaborative design project challenge required the students, as a collective class, to work on the development of a model railway carriage. Initially, as a class group they were to draw a carriage for a 1 gauge model railway track. One carriage from each school was printed. The school was provided with a set of bogeys, and the carriage (along with all the others) was run around the track at the Luddenham Model Train site in NSW Australia. The carriage designed was then returned to the school so students could reduce the scale (to be decided) of their drawing, add some wheels and it was printed as a memento of the challenge. This was a within class collaboration.

As a collective group the students were expected to discuss with their teacher and mentor some of the issues associated with any of the proposed designs, such as track curvature, tunnel sizes, purpose of the wagon/carriage, different issues associated with the variety of 1 gauge standards, speed, centre of gravity, strength, etc… As a collective group they needed to clearly demonstrate the viability and appropriateness of any proposed designs to the teacher and mentor, prior to modelling the design. This was to be done via drawings, prior to computer modelling, as generally occurs in the industrial commercial world. The student groups files had to be confirmed as readable prior to being rapid prototyped. Further, as a group they were expected to understand the nature of the limitations of the rapid prototyping process, and 1 gauge model train wagon/carriage design in order to realise their design. As an example, material wall thickness should be kept to a minimum of 1.5 mm, allowance for the physical limitation of the rapid prototype materials, nesting of parts etc… Subsequently, they were to have the design rapid prototyped. Once this was done, parts/kits were returned to each group [student teams from various locations around Australia].. They sent the final design to the organisers [Bossley Park High School] for review, plus coupling and bogie fit testing. Carriages were assessed according to the criteria; the designs were to be innovative, they must work, and they must be both visually and mechanically elegant. Further, they needed to be compatible with the couplings and bogie details, which were supplied. The carriages sent for printing and inclusion in the collaboration train, met all the criteria to a high standard.

Project One involved all ten schools (10 teachers, and 12 classes the size of which varied from 20 students per class to 4 at the Distance Education School, approximately 170 students involved), the cohorts included a Year 12 Engineering Studies class, a Year 11 Design and Technology class, Graphics classes in Year 8-10 and Technology classes in Year 8. Each school developed their own model of collaboration, ranging from a simple model in which each student drew a carriage and the class decided upon which would be sent for printing and subsequent inclusion in the collaborative train, this was the most common approach through to, each student drawing a single carriage component class assembling, as was the case in the Mail Carriage drawn by The Riverina Anglican College, Wagga Wagga.

Project Two

The second collaborative design project related to the development of an ergonomic hand driven computer cursor control artefact for less able physically impaired users.

This collaborative challenge required the various student groups around Australia to design an optical pointing device for some-one with a disability. Schools were paired up and needed to collaborate on the design and drawing of the device, all schools would be sent the innards of an optical mouse, it is hoped that the device would remain functional. Sets of schools [groups of two paired schools] formed mini clusters. Schools were paired by negotiation with the project co-ordinator and the participant teachers. The roles undertaken by each school in the mini-cluster were determined by the individual teacher in each school. Teachers based their decisions upon which role they best saw their students undertaking, given the differing nature of the classes. The performance in the preliminary project played no part in determining the pairing of schools. The project co-ordinator formed mini-clusters using the determining factors of school size, diversity of cohort, and geographic location after teachers had decided upon which role their students could best fill.

For example; in one mini cluster, the Year 11 Design and Technology class (24 students) at Bossley Park High School (Sydney, NSW) took on the Industrial Design office role, and the Year 10 Graphics class (20 students) at Mossman State High School (Far North Queensland) took on the Drawing Office role. This negotiated pairing enabled students to achieve course outcomes as well as project outcomes.

Students were provided with a real life design problem which provided an opportunity for collaboration on a more complex problem. The collaboration has been structured so that students although being part of the whole design team, form subgroups of specialisation, that is students in one school perform as consulting Industrial Designers, researching the problem, developing solutions, sketching, and making mock-ups before handing over their initial ideas to students in the partner school, who were the 3D drawing specialists. The sketches and mock-ups are then uploaded to the web via the collaborative on-line tool Windchill Projectlink.

So students may gain valuable learning experiences that are as close to how global corporations operate as possible taking advantage of the notion of collective intelligence both within teams and between design teams, they were to work as a team within their school and were paired with another partner school. Generally, this partner school was a great distance away requiring communications to take place via the internet tools taught to, and practice by, the students. The students had to imagine their design team is part of a company that has recently been bought by a major international corporation. This corporation owns other companies strategically positioned around the world. They operate in a similar way to their company [a given school], however, now their team must work with two other companies, one was their partner school and one is the manufacturing centre [Bossley Park High school] headquarters and prototyping facility located in Bossley Park, NSW Australia. Each school's team in consort with their partner team, from their partner school, designed and developed an ergonomic hand driven computer cursor control artefact for users who are less able physically. Additionally, the resultant design needed to be aesthetically pleasing, appropriate, visually elegant, and mechanically elegant. Moreover, it must be robust, functional, reliable, and safe. It needed to be easy to assemble/disassemble, with an appropriate number of parts. Each school team was given the core optoelectronic components that were to use in the design and development of the device. The teams were expected to document their design process in detail. Each school team was to maintain a detailed Process Journal. In this project the internet communications skills they developed, via collaborative experiences in the earlier projects, would assist in tracking the design process in conjunction with their respective partner school and aid in the development of the journal. This also allowed teams, teachers and student mentors to monitor issues and problems that have developed during the design and development process. Thus new collaborative procedures evolved in the fullness of time. Students were to imagine the teacher and student mentor were representatives sent by corporate headquarters to monitor and assist in the development of the company's new cursor control device. As the imagined corporation was described as a large corporation, they had put together other partner teams from other subsidiaries. These other teams were competing for the 'green light' to develop their control devices. While each collaborative group's design was to be prototyped, the board of directors ultimately selected the best and consequently least flawed design to put into production.

Project Three

The third challenge was a multi-part mechanical toy. Schools were grouped together in a much larger group. Each school was to design and draw a part for the toy and collaborate with the others in their group as to fit and functions [how the toy works] etc.... In this project, two teams were formed by the project co-ordinator to diversify the mix of schools taking into consideration, type, size and location. Each team consisted of 5 schools, made up of a teacher per school, approximately 60-70 students per team, and the cohorts ranged from Year 11 to Year 8

This project was a simulation of a 24 hour office, whereby the project was passed from school to school to design individual parts for the challenge. The original project set out to be a mechanical toy, but after consultation with teachers in the cluster schools, the project was changed to that of a scaled fairground ride. It was the general consensus of teachers involved that this would be more interesting for their students.

The various student groups [teams] had to design and produce a scale model of a "Fun Fair Ride". This third project was divided into two distinct stages. In *Stage 1* students collaborated on the design of the concept for the mechanism and structure of the fun fair ride. As a total group, using their collective intelligence, agreement on just what TYPE of ride was to be developed had to be finalised. It is important to note that a later part of the challenge would require the students in individual schools to create their own "gondola" (The part of the ride that people will sit in).These were developed in 3D CAD form and confirmed by all schools before the structure was 3D printed. In terms of their collaborative process, student groups were to sketch (on paper) individual designs for the ride. They were instructed to develop as many ideas as possible. Further, they were told to be as creative and as weird as they fancied, for in the end good ideas would inevitably be generated. Subsequently, the student groups identified and selected some promising sketches, revising them into ORTHOGRAPHIC sketches with some sizes on them, deciding upon a scale.

Once the drawings stage was complete, as a group, each school decided which of the class's designs will be shown to the other schools. Scans of the selected designs were uploaded to the WINDCHILL site. These could be graphics inserted into word, or scanned images saved as jpg, png or gif files. After all uploads were complete the schools discussed, using WINDCHILL software, the design they ALL preferred.

This constituted the first stage of collaboration between schools. After the overall design concept of the 'Ride' was determined, the project was initiated by one school using 3D CAD software to refine the design. Subsequently, it was passed to every school in turn, according to an agreed timetable. Therefore, each school's CAD drawings (parts) needed to be uploaded to the WINDCHILL software. Progressively the schools downloaded the files and develop the designs further. After 2 weeks of work (per school), the finalised design was translated into an STL file and printed.

In *Stage 2* the specifications for each "gondola" was agreed upon by the teachers involved. Each of the schools was tasked to work on designing separate gondolas to be attached to the ride. A common specification needed to be negotiated. For example issues such as sizes and volumes needed to be communicated between students. Further, students needed to collaborate and agree precisely how each gondola was attached to the ride, and how the ride would operate needed to be made very clear to everyone. After the final design for the ride was determined, students immediately started to work on designing the gondolas. They develop their gondola designs utilising the drawings of the ride, with the gondola mounts clearly specified and the scale and sizes specified. Work on the gondolas was initiated by each individual school. Each "iteration" was placed on the WINDCHILL collaboration site for students at other schools to "improve" the designs. This iterative and collaborative design work continued for 3 weeks. At that time the most advanced gondolas were 'checked out' of WINDCHILL and printed.

Implications for Teaching and learning in the classroom

There were significant benefits gained by the interaction of teacher mentors with students throughout the project. These included,

- School students were exposed to young people who have chosen to enter the field of design education and were able to talk to them about university life and the challenges of further education.
- Teacher mentors were able to practice delivering information to school students in a non-threatening informal atmosphere not necessarily found in a prac teaching or intern session.
- Teacher mentors had the opportunity to discuss issues surrounding the delivery of Technology education with experienced, enthusiastic practitioners.

Students at ACU are developing a collaborative project as part of the teacher education degree.

Teachers participating in the project developed a network of support and resources that spanned state and system boundaries. Resources that were developed as a consequence of the project were shared not only with people within the project but to a global audience through the project website. A case study completed by researchers from Deakin University provided the following feedback:

> Another clear outcome was teacher professional development. The project has tried to maintain a sense of continuity in terms of the ideas and practices that have been successful, and to keep in contact with a network of people who will sustain this continuity.(Susan Rodrigues Deakin University 2008)

The project has also provided an opportunity for teachers to move away from traditional ways of achieving curriculum outcomes, they have had an opportunity to explore new technologies and interact with teachers outside their own teaching community, this is also true of students participating in the project.

The following comments have been drawn from the case study conducted by Deakin University ;

> I think it excites the teachers too, you can see them working it out in their head,
>
> "what can I use this to do?". Firing them to move them outside what they traditionally do. As Industrial Arts teachers we have got to be looking at new technology and this provides them with an opportunity to do that and apply it in ways that they might not have done. They are often surprised by what the kids can *do*. (Teacher 1, June 2007)...
>
> The collaboration across schools and between schools and industry was a significant outcome. ... To have access to this technology and work in cooperation with Bossley Park enables them to use cutting edge technology in their technology education classes. In addition, overall this project is helping students to develop skills that will be useful beyond the classroom. (Susan Rodrigues Deakin University 2008)
>
> "So in their workplace twenty years from now that is the learning that they will still have. It doesn't matter if they are in engineering or not." (Peter, Head of Faculty/Teacher, June 2007)
>
> "Giving us a good scope of the profession, what engineers and designers do together as a team. It is a team thing. Engineers would do one thing, designers another." (Student 4, June 2007)
>
> "Imagination, let that run wild, you can pretty much do anything with that software." (Student 1, June 2007)
>
> "It is kind of nice to see the sort of work that other students are turning in." (Student 3, June 2007)
>
> "... certainly from the design perspective that is how a lot of design is done this day. So if we are in the business of producing graduates from high school who are going into the real world,

we have to try to give them some realistic skill base. If they go into the design area some of them will have experienced this." (John, Critical Friend, June 2007)

Results and Findings

This study has demonstrated the development of collective intelligence, as defined earlier, can be effective in advancing design and technology education in secondary schools. Initially, via the conference, the representatives from the partner organisations clearly demonstrated the capacity for working collaboratively in the development and refinement of the design tasks. The resultant collective intelligence allowed the group to structure the learning experiences of the student cohorts in a meaningful way. While the key tag exercise was clearly aimed at skill development within each individual student encouraging them to collaborate with the 'Manufacturing Centre' by sending their computer model file for 3D Rapid prototyping, in-depth interviews/consultations with the partner schools, in which students have sent key tags to the manufacturing centre and subsequently received the 3D models, reported that students were very excited. In fact teachers were also excited and impressed by the results. Exemplars of a key tag computer models are in Figure 1 below.

Figure 1 Sample Key tag computer models

The key tag project had a two fold effect in that students were able to experience the difference inherent in various types of stereo lithography and also injected enthusiasm for the next phase of the project. The Rapid Prototyping machine has proven to be extremely simple to use and very reliable. Several schools were involved in the development and sharing of resources for this particular design challenge. For example, information on how to create an STL file from the drawing software into a form which enabled the 3D printer to read the object. Additionally, a programme from Gympie State High School on Graphic design, concentrating on logo development was shared. The programme, while not initially written for this project, provided resources which could be easily tailored toward the introductory task (the key tag project). This positive response notwithstanding, the response to the introductory task of designing a key tag and sending it to the manufacturing centre was very slow and not all schools have managed to achieve this, although discussion with the teachers in these schools indicates that their students have in fact been working on them. While some schools dropped out of the key tag project they rejoined it later in the program, hence the fluctuations in the number of teachers, students and student mentors.

The development of collective intelligence within each class was the central aim of the first major collaborative project between collaborative student class groups within each individual school and the manufacturing centre. With respect to the first major project 'Railway Carriage', the students experienced a class collaboration of design and drew one toy train carriage per student, using PRO/Desktop PRO/Engineer or any other 3D CAD software. Students were given a design brief developed collaboratively at the teacher conference. The students experienced converting files to .stl and sending them to a distant manufacturing centre for production (3D printing), having them return for evaluation and refinement. One carriage from each school was chosen to make up the collaboration design solution. This learning experience was a direct parallel to what occurs in the industrial commercial world. It was exceedingly clear the students had developed an ability to adopt various perspectives and heuristics in the resolution of the design task as they collaborated on an agreed design solution. This is useful as an example when disseminating information within secondary schools. Figure 2 below is a photograph of an exemplar 'Railway Carriage' that was Rapid Prototyped.

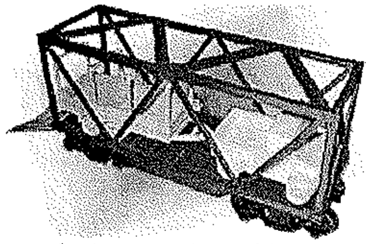

Figure 2 Sample Rapid prototyped railway carriage with bogeys attached

The central aim of the second major project was to develop collective intelligence capacities not only within individual student and among a group students [within a class of students], but to develop collective intelligence between groups of students operating at a distance in another school. Students in the two schools had begun collaborating on the development of their solution to the problems. Students had many great opportunities to experience, learn, and develop the capacity to clearly and concisely communicate their design ideas. They employed a design process to research, analyse, sketch and use mock-ups to develop design ideas to help solve the problem. This study allowed the students to be challenged by rich authentic tasks which has enabled them to develop skills in; innovation and creativity, reflection and evaluation, application of conclusions of research and experimentation. The second design task served to further add to the new perspectives and heuristics [collective intelligence] the students had gained from engaging in the first collaborative design task.

It was the third project which most closely related to the industrial commercial perspectives with respect to the used of rapid prototyping and the development of collective intelligence. As indicated earlier, global corporations take advantage of the notion of collective intelligence both within teams and between design teams. In addition they take advantage of modern technologies such as internet communications and rapid prototyping facilities. The experiences gained in the third project clearly allowed each student to self actualise their personal problem solving abilities. Additionally, it was clear the 'Gondola' design problem was resolved by groups of people working in a synergistic way, in order to develop solutions to problems presented to a group of individuals, or groups of individuals. This third design problem drew upon each individual student's knowledge base, creative abilities, and shared understanding / identification of the problems constituent parts. As the project progressed, these individuals operated as a synergistic whole. This, as per our earlier definition, demonstrated the student groups from around Australia and involved in this study, developed a 'collective intelligence'.

Various experiences, throughout the study, allowed the students to develop their capacity for working collaboratively, extending the groups collective intelligence. For example, there were opportunities to experience and practice uploading files to Projectlink enabling both student and teacher/mentor collaboration to take place, as it occurs in the Industrial commercial world. It was clear the professional discourse regarding drawing and modelling for production and drawing and modelling for presentation effected changes in student output in drawing classes. These outcomes demonstrated the students had progressed from "drawing for presentation" to "drawing for production". Teachers and students have been exposed to and utilised cutting edge industrial processes. Teachers have utilised a student centred project based teaching model involving creativity and innovation, providing opportunities for "risk taking" within their classes. Additionally, it was observed students were very enthusiastic when using the Windchill project link software and keen to see how other students approach the same problem. In a real sense this assisted in the emergence of student centred collective intelligence. Further, it was observed the response of students involved in the project and their perceptions about the value of the project for their future university studies and employment prospects in the field of Engineering had grown, during the course of the activities.

Despite the difficulty with the machine and the production of the models, teachers and students in schools had been drawing in 3D CAD, they have been discussing 3D rapid prototyping technology and had developed an understanding of industrial commercial processes and collaboration with others away from their site. Students had recognised that distance is not a barrier to communication and production, that discussion, development and revision, or the iteration of design can occur at many sites and come together. Students in varying schools had reviewed the work of others; developing an understanding that the idea of a national standard in the area of 3D CAD modelling is ongoing and developing. Additionally, teachers have had some occasions to use leading edge communication technology (WEBEX) across the internet.

Teachers and students have developed their ICT skills via tele-working, Computer Aided Designing and remote manufacture of prototypes. They had worked to specifications developed by others and engaged in social interaction with teacher mentors, industry representatives and other students in locations different from their own. This was greatly assisted via Project Management Meetings using Webex to teleconference between Project leaders. The professional development they have received has enabled them to develop further units of work involving CAD CAM and CIM for their students and their colleagues around Australia.

There was a large increase in teacher professional development, among teachers outside the project, in relation to the use of CAD/CAM technologies. Additionally, a clear growth in support for each other in the delivery of technology education and co-operation was noted both between teachers across systems, and between states. Technology teachers are faced with an expanding rapidly changing field of operations, as there is now a huge growth in knowledge beyond the traditional. The development of resources which are able to be modified to suit the particular needs of different various technology education syllabi has served to strengthen the quality of education being delivered throughout Australia. The development of communication links between teachers, universities and manufacturers and suppliers in the leading edge industry has led to sophisticated professional discourse, resulting in the development of a 'Collective Intelligence'.

This study demonstrated the strategy of using purposeful and progressive design tasks in conjunction with Rapid prototyping technologies is an exceptional vehicle for pooling/sharing divergent perspectives and heuristics [developing collective intelligence]. Further, we would contend this strategic combination is a powerful educational tool, as the students who actively engaged with the collaborative design tasks had evolved and developed a capacity for using collective intelligence in a classroom context. Additionally, we assert cooperative learning and collaborative problem solving are effective in improving academic and social skills, as it is often the case students, operating in the context of technology education, do not experience collaborative design in the same manner as globalised corporations which develop products for distribution around the world. This study demonstrated using purposeful and progressive design tasks in conjunction with Rapid prototyping technologies assists both teachers/academics, and students in identifying design issues/problems, formulating ways to address them by taking advantage of, and using, collective intelligence in a classroom context.

Acknowledgments

The authors would like to thank the ASISTM granting body, and the Federal government for their financial support in relation to this important research. The authors would like to acknowledge and thank all the people who have aided in developing, progressing and guiding this major study to its conclusion. Everyone associated has made a sterling effort to advance the educational opportunities for Design and Technology students around Australia. We especially like to thank the following who so willingly gave their time and boundless energy to this study: Chris Burton, Peter Thompson, Tony Skimmings, Roger Forsyth, Graeme Mell, Adam Possingham, Paul Trebilcock, Jim Murdoch, Malcolm Lee, Jeff Appleby, Ivan Chester, John Barlow, Greg Sisk, Michael Brown, Kevin Mackin. Further, we would like to acknowledge and thank all of the Teacher Associates and students who earnestly endeavoured to work through the learning tasks that had been developed. If we have missed anyone who has played a role in this undertaking, it is purely accidental. Please accept our sincere apologies. Again well done all involved.

References

Department of Employment Education and workplace relations, Tytler, R. Symington, D. Smith, C. Rodrigues, S. (ed.) 2008, An Innovation Framework based on best practice exemplars from the Australian School Innovation in Science, Technology and Mathematics (ASISTM) Project , Educational Futures and Innovation: Science, Technology, Environmental and Mathematics Education (STEME) Research Group, Deakin University, Govt Printer, Canberra.