A practical approach to exploring different making and learning approaches

Science Technology Innovation (STI) and Doing Using Interaction (DUI).

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Background

There has been much debate over recent years about different pedagogical approaches to learning and guiding principles in the field of learning, making and creativity. Twentieth century theories on innovation have been grounded in empirical study and scientific coded knowledge. However, established models of innovation have been disrupted in the twenty-first century with the increased interest in emergent models including open innovation, sharing risk and rewards, moving from models of ownership to access, growing evidence of social innovation and frugal innovation. One size no longer fits all. One encapsulation of this movement from formal learning back to experience-based creativity that cuts across craft, design, engineering and innovation has been recently described by a number of authors. The Science, Technology and Innovation (STI) mode is based on the production and use of codified scientific and technical knowledge. The Doing, Using and Interacting (DUI) mode relies on tacit knowledge, informal processes of learning and experience-based know-how.

STI

- Know-what: Basic understanding and information about the world (for example, watering a tree makes it grow).
- Know-why: Scientific understanding of laws and principles that govern the 'what' (for example, the chemical reactions that cause water to make a tree grow).

DUI

- Know-how: Less interested in why it happens than that it happens. A set of skills and competencies acquired through experience (for example, watering a tree in a specific way and at specific times help it grow best).
- Know-who: Personal relationships with others – knowledge acquired through a community and the social skills to interact with community (for example, a network of knowledgeable tree growers that exchange tips to help each other grow better trees).

Introduction

Investigations into the differences between the STI and DUI modes of learning and creating have, up to now, been largely theory-based or through academic analysis of existing practices. This paper describes the development and assessment of a more practical approach to exploring the differences between these modes. The approach uses two teams working in parallel with different constraints towards the same goal. The overall aim of the exercise is to introduce the participants to the STI and DUI modes in context through structured learning with real world application and lessons. The hypothesis is that, given the same challenge, two teams with different controlled learning environments will behave differently, produce different outputs and have different experiences.

Approach

The authors designed an experiment that split the participants into two teams and asked them both to make paper parachutes in 15 minutes. The teams worked independently with different instructions and processes to follow. They were told that their parachutes would be scored at the end of the exercise on the basis of the duration of flight, stability and ability to carry a payload. Each team had the same number of people, the same male to female ratio and access to the same resources: A4 paper, string, paper, rulers, glue, sticky-notes, pens and jelly sweets to use as payload. No specification was given as to whether teams should make one or several parachutes, but the teams were briefed that they would each be allowed a maximum of three attempted parachute drops. Although no prizes were offered, the teams assumed a competitive mind-set.

The teams were not given any tuition about the STI and DUI modes (the title of the workshop was 'Problem-solving with Paper prototyping') but the instructions were designed to constrain and encourage the teams to work in one of the modes. The teams are described here as STI and DUI however they were not aware of this deliberate allocation until after they had completed the challenge. The exercise was facilitated to ensure that the teams kept to time and to their instructions.

Sprint	STI team instructions	DUI team instructions
1st Five Minutes	Read document on paper parachutes and discuss	Build and test parachute(s)
2nd Five Minutes	Design and build parachute(s)	Learn from each other, build and test parachute(s)
3rd Five Minutes	Build and test parachute(s)	Build and test parachute(s)

Table 1. Instructions for the STI and DUI teams.

The instructions for each of the teams are shown in Table 1. The DUI team was encouraged to start building and testing parachutes immediately and to share their experiences with each other. The STI team was prevented from building parachutes in the first 5 minutes and only allowed to test their prototypes in the last 5 minutes. The STI team was however, provided with a knowledge resource not available to the DUI team.
The STI team knowledge resource was a printed two-sided A4 document that described some of the early history of the parachute going back to Leonardo da Vinci. The document described how the original parachutes were rigid in construction and that a vent hole is often used in the centre of the canopy to aid stability. The basic physics of a parachute were described indicating that larger canopies fall more slowly and can carry a greater load. Finally, the document provided two examples of how to make a parachute with string and paper.

Once both teams had completed the three 5 minute sprints they came together to drop and score their parachutes (Figure 1). Once this stage was complete, the participants and facilitators discussed the exercise as a group. The participants were given more information about the STI and DUI modes to and asked to reflect on how their instructions had influenced their behaviours.

This exercise was first run at the Making Futures conference run by Plymouth College of Art on 25 September 2015. The exercise has since been repeated at Aberdeen University by Dr. Bruce Scharlau, Senior Teaching Fellow in the Computing Science Department, and at the Food Standards Agency by Andrea Sidmiok, Director of the Cabinet Office's Policy Lab. The qualitative results and observations shared in this paper are from the Making Futures conference where the exercise was facilitated by the authors. The questionnaire results also include data from the Aberdeen University session.

Figure 1. Participants testing parachutes at the Making Futures conference.

Assessment

The assessment of the ability of the overall approach to highlight differences in the STI and DUI modes is strongly interconnected with the assessment of the outcomes of a specific exercise. In the first instance, the outcomes of the specific exercise are described and the assessment of the overall approach is discussed later.
The following data capture and analysis techniques were to test the hypothesis that the two teams would behave differently, produce different outputs and have different experiences:

1. Team behaviour: observation of team dynamics and individual behaviours during the process;
2. Artefacts created: scoring of each parachute drop (flight duration, stability and ability to carry payload) and analysis of the parachute designs created by the teams;
3. Self-evaluation survey: completed by individuals at the end of the session;
4. Group discussion: after the parachutes had been scored and the STI and DUI modes had been explicitly described.

Team behaviour

The different innovation learning styles in the experiment were deliberately not revealed to the participants until the end of the session so as not to influence behaviour. Both teams performed well under pressure.
The DUI team members sought clarification and asked questions such as 'Does it matter what size the parachutes are?' and 'Can we use any of the materials?' whilst gathering materials. The team members then started making paper structures immediately and conversed with each other, for example, 'I am going into auto-pilot mode until someone stops me.' They compared techniques and approaches with each other but chose to build their own individual parachutes.
The STI team chose to read the instructions in silence before discussing with each other and asking 'Do we have to follow these instructions?' The team members talked collaboratively, and assessed resources. They did not start building as soon as they were allowed and did not test anything. They requested a five minute extension at the end for more building time. They also chose to build individual parachutes.

These examples that have transferred through these different stages of materiality, (physical –digital) carry with them a patina and visual trace of their transference from human hand to program software, from screen to textile, and back again. Figure 3 illustrates the aesthetic qualities of digital glitch. The original photograph of fabric is encoded and the file corrupted through digital processes. The resulting image mediates the physicality of the original image with glitches that are determined digitally. This connects visually with what Thrift (2005) refers to as a new reality in describing this kind of materiality as a new means of imagining the world, a new kind of reality that depends on combining the new senses of 'human' and 'material' that have come to exist.

Artefacts created

The parachutes from each team were scored on a scale of 1 to 5 on flight duration, stability and size of the payload (number of jelly sweets). The scores for each category were then summed to create a total for each parachute drop.
The 'winning' drop was from the STI team however the DUI team scored highest overall when considering all three drops.
The DUI team produced parachutes with a wide range of different features but some shared features were evident. The parachutes from the STI team were more uniform and less complex.

Self-evaluation survey

All team members completed a short survey with simple closed questions on a scale of 1 (low) to 7 (high) to get a snapshot of feedback on the process, based on their own individual experience of the exercise:

1. How rushed did you feel?
2. How fun was the exercise?
3. How well did you collaborate?
4. How far do you feel that you were able to harness experience of individual team members?
5. To what extent did you feel you explored all the possibilities?

	Making Futures conference		Aberdeen University	
	STI	**DUI**	**STI**	**DUI**
Qu. 1	How rushed did you feel?			
	5.3	6.7	5.4	3.8
Qu. 2	How fun was the exercise?			
	6.7	6	6.4	6.6
Qu. 3	How well did you collaborate?			
	5.3	3	6.2	5.8
Qu. 4	How far do you feel that you were able to harness experience of individual team members?			
	4.7	3.7	5.8	5.3
Qu. 5	To what extent did you feel you explored all the possibilities?			
	3	2.3	3.2	3.9

Table 2. The mean scores from the self-evaluation questionnaires for two different sessions.

The results from two sessions are shown in Table 2 and it is useful to have this comparison of independent exercises. Importantly, it can be seen in question two that all the teams enjoyed the experience, which provides a good basis for positive learning if the lessons are relevant. The participants in the Aberdeen University session were students while the participants in the Making Futures conference were mainly older academic professionals. This may help explain the wide difference in how rushed the DUI teams felt (question 1) with the younger team more comfortable starting with just glue and paper.

The questionnaire also poised two more qualitative, open questions to ask if any breakthrough moments occurred and to explore any lessons that the participants felt they could take from the exercise. These are summarised in Tables 3 and 4.

Qu. 6 Any innovative breakthrough moments?	
STI Team	**DUI Team**
'Changing diameter of hole in the middle.' 'Agreement on approach.' 'No.' 'Hole puncture, string attachment.' 'Changing how instructions were presented.' 'A bit.' 'No.'	'Twisting and spiralling.' 'I needed sugar (jelly sweets).' 'No.' 'Bigger parachute.' 'No.' 'Design of box. Shape of parachute.' 'Testing while making lets you improve faster and get better results.' 'Refining the design to a lighter version.'

Qu. 7 Is there any learning from the session that you think can take away and apply?	
STI Team	**DUI Team**
'Yes.' 'Using people's skills.' 'Yes.' 'Collaborative working. Momentary innovative thinking development.' 'Teamwork.' 'More time gives a better design. Contribution of all members.' 'Team work under time pressure.'	'Experience versus knowledge.' 'Good what can be achieved in a small team - just try.' 'Try, and do not fear.' 'Try and test more.' 'Listen even when focus on something.' 'Teamwork and cooperation.' 'Following the rules is not always best.' 'Listen!'

Table 4. Quotes from the self-evaluation questionnaires on lessons to take away.

Group discussion

As already described, the Making Futures participants had largely an academic background and had experience of teaching. They recognised that individuals with different learning styles would be more comfortable in the STI or DUI environments. As individuals, those with an academic background preferred to be somewhat proficient or to have conducted some research in an area before starting to design (more STI). The individuals with artistic and entrepreneurial background were happy to play and do first (more DUI).

Individuals in the STI team who had an academic background identified that they initially felt more comfortable with the instructions but that these did fix their frame of reference, potentially limited the scope of solutions that they could investigate in the time.

All the participants recognised the different approaches characterised in the exercise and appreciated that a mix of both would be optimal in most real-world scenarios. They described different research, learning and teaching scenarios where a conscious flip from one mode to the other would help to improve results or engagement.

One participant suggested that a simple matrix describing the different approaches would provide a reminder to ensure that tasks and activities were better balanced for the different styles. This may present an avenue for future research – comparing a mixed STI/DUI approach with the two extremes tested here and creating practical tools.

Observations

The behaviours of the two teams were different. The DUI team questioned the brief harder and started building immediately. The STI team discussed more between the team and assessed their resources theoretically rather than practically. The teams showed a similar balance of collaborative and individual behaviours.
Both teams chose to build individual parachutes. It is likely that this was influenced by the coincidence that the number of trial drops allowed was equal to the number of team members.

In the parachute scoring, the DUI team made parachutes with better (longer) fall times. This was the criteria (compared to support mass and stability) that they could test very quickly and intuitively within the timespan of the exercise. It is interesting to note that the winning individual drop was within the STI team. It may be the case that the instructions gave the confidence to put more time into a larger more risky build compared to the iterative improvements of the DUI approach.

In both sessions the STI teams felt they collaborated more effectively and better harnessed the experiences of all the members of the team (questions 3 & 4). This could be seen as counter-intuitive to those who use group making activities for team building but it is likely that assimilation of the codified knowledge provided a common experience for the STI teams. The reported increased in collaboration is also found in the comments of the teams in relation to lessons learned (question 7) where there is a stronger bias towards topics of teamwork from the STI teams.
The teams' comments on the innovative output of their work (question 6) indicate that they were reasonably similar and this is supported by inspection of the artefacts created.

Limitations

The exercise was conducted both as a learning experience for the participants and as an experiment. Even as an experiment there were two objectives: to investigate the potential using the STI/DUI paradigms in learning research and to establish whether a simple process would provide different outcomes for the approaches. Good progress has been shown on both objectives and developed a useful platform for future practical research; however any further work should have a more focused scope.

The selection of individuals for each of the STI and DUI teams was random; however the individuals who attended the Making Futures session had self-selected to attend the conference and then chose this particular stream within the programme. Any future practical research in this area should aim to understand the STI/DUI paradigms in different populations.

The time and number of people available for the exercise was limited. This prevented the use of multiple groups and any investigation of how a priori knowledge of the STI/DUI paradigms impacts behaviour. The teams all felt rushed and it is likely that 90 minute sessions would provide optimal conditions for future work.

Conclusion

Using small groups in relatively controlled conditions, our initial findings indicate that people do behave differently and approach problem solving differently in STI and DUI settings. In addition, the participants enjoyed the experience which gives this process the potential to be developed and deployed further. As well as effectively demonstrating the different STI and DUI modes, the method described in this paper showed that the teams using both approaches were able to successfully complete the task in a short time window across multiple sessions.

As discussed, there are clearly benefits and shortcomings to both sides of the STI/DUI paradigms; lessons can be learned from both and the deliberate use of both approaches is likely to give the best overall outcomes for most individuals in most scenarios. Science, Technology and Innovation (STI) has for a long time been recognised as one of the main drivers behind productivity increases and a key long-term lever for economic growth. However the value of more practical, tacit modes of creativity such as Doing, Using and Interacting (DUI) are being recognised, challenging the codified innovation pillars of the twentieth century. These experience-based approaches are increasingly recognised in the development of a service economy and in seeking value beyond the narrow definitions of commercial growth.
In an increasingly digitally-enabled and data-rich society we are connected both by our collaborative behaviours and our access to data and knowledge. An explicit understanding of how best to combine these approaches is essential if we are to make the most of changes that technology will bring.

References

Cooke, P. (2013), 'Towards DUI Regional Innovation Systems', PEEG 13.21.

Jensen, M., Johnson, B., Lorenz, E. and Lundvall, B.A. (2007) 'Forms of knowledge and modes of innovation', Res. Policy 36, 680–693.

Lundvall, B.A. (1992) National Systems of Innovation, London: Pinter.

Parrilli, M.D. and Elola, A., (2012) 'The strength of science and technology drivers in SME-based innovation', Small Business Econ. 39 (4), 899–909.

Radjou N. and Prabhu J. (2015) Frugal Innovation: How to do more with less, London: Profile.