Dr Mary E Richards
School of Arts
Brunel University, Uxbridge, Middlesex
UB8 3PH, UK

Joining Forces: Engineering and Arts students get physic(al) – problem solving strategies in the trans-school project

Keywords: transdisciplinary, arts, engineering, problem solving

> "In practical terms, most creative processes benefit enormously from collaboration. The great scientific breakthroughs have almost always come through some form of fierce collaboration among people with common interests but with very different ways of thinking."
>
> (Azzam, 2009: 24)

> "Roe (1952) argues that a creative person has the capacity to generate unusual associations. This means that a creative person can find connections between disciplines and cultures, which are not obvious to other people"
>
> (Byrge and Hansen, 2009: 238)

Within the overarching frame of the trans-school project carried out at Brunel University and discussed in papers by Schiller and Smith in this same conference proceedings volume, this paper considers as case studies, the process and work developed by two small group workshops with arts and engineering students. It notes the range of approaches to problem-solving when both groups are faced with the task of working with a physics principle to create a short performance.

The first of the two workshops later identified as the 'force' workshops, worked almost exclusively with arts students – all of whom were post graduates and all well versed in the principles of performance making. The familiar environment of Brunel University's Antonin Artaud Centre performance spaces provided the backdrop for their rehearsals and presentation; in other words there was nothing particularly challenging to them in the physical circumstances of this workshop. What was different however, was the primary

stimulus given to them; a short lecture from a physicist (Dr. David R Smith) on the four fundamental forces. This presentation essentially conformed to a conventional model of knowledge transfer. It covered gravitational, electromagnetic, and nuclear (strong and weak) forces describing their relative strengths and giving visual examples of how these forces functioned in relation to bodies and objects. For the students Smith was addressing, these were probably concepts not encountered discursively since secondary school.

Following the lecture, students were asked to consider what force meant to them before working pairs were formed; one of pairs was made of a Masters student and Smith. This was the result of the uneven number of arts students attending the workshop, and Smiths' willingness to participate. The other pairs consisted of; a visiting post doctoral fellow working with a Masters student, and two further Masters students. The pairs were asked to make a short (3-5 minute) piece that elicited some form of interactivity from the audience. The three pairs then had a number of hours to work on their piece with members of the project (engineering and drama staff) on hand should they wish to discuss any matter with them. The whole process was documented with a number of video cameras.

The first of the three pairs (consisting of Smith and a Masters student) spent much of their process time seated on the ground with pen and paper; both members contributed to the discussion and a basic frame for their performance was soon arrived at. Floor-based discussion dominated the process even when Smith attempted to move from the largely stationary seated position both had adopted to a more physicalised engagement with the ideas they had generated. In this respect, the arts student was more reticent than the scientist she was working with. By contrast the post doctoral and Masters student combination moved swiftly from an exchange of preliminary ideas to experimenting with movement and the specific concepts of force identified as interesting to them. It should be noted that both these students are trained in dance and arguably are more likely to move to the physicalisation of their ideas more quickly than others without this background. In addition, English is not a first language for either of them so action is likely to have spoken louder than words in any case for this pair. The third pairing of Masters students also preferred to practically engage with the ideas from an early stage of the development of their piece; however it was notable that they continually punctuated their movement experiments with discussion; they rarely sat to do this, but stood or demonstrated to each other to clarify their thought process. All pairs appeared to establish a rapport with relative ease even though only one of the three pairs were familiar with each other before the workshop took place.

The first pair (Smith and Masters student) decided to work with an end-goal premise that had a low, but non-zero probability of success. Audience members were asked to participate in the piece and were instructed to walk through the space in 3 different ways determined by the performers or initiators; on the first occasion this was done with the audience members eyes open, then with eyes closed and finally with eyes open again. During the

action, the performers, through their own interventions on individual audience members, were trying to re-establish the particular spatial formation they had started out with. The immersive nature of their presentation meant that the outside eye of the video camera provided a fuller picture of events unfolding; each individual taking up the role of performer in the piece, being unable to fully appreciate what was being attempted. The video document, itself a very partial record, was then turned to as a means of gaining a picture of how both the principles of force and the spectator/participants were interacting.

The second pair (post doctoral and Masters student) asked the audience to take up a position within the presentation space, either standing or sitting. There were no further instructions during the movement sequences that followed. In other words, the primary interaction was between each other, while the audience observed and occasionally became an object between the two performers. There were no instructions for audience members to intervene or interact with the performers so audience members remained passive observers of the actions between the two. This pair additionally added objects to their presentation; bringing a sock full of sand to the space and creating a floor drawing with the poured substance during one section of their presentation. Because the emphasis was on the performers themselves moving through the space with spectators as observers, it could be argued that this was the most conventional presentation of the three. In the discussion that followed the conclusion of all three presentations, Smith observed that to him elements of Kepler's laws of orbital mechanics could be identified in their movement choices. This was noteworthy because of what this statement revealed about the interpretative framework in operation for different individuals all faced with the same performance. In this instance Smith's response was in keeping with a physics lens that colours his experience of the world. However, while one of the performers in the piece Ollala Lemus spoke of the symmetry and tension they had wanted to create, the second performer Maira Spangero pointed out that they deliberately avoided enacting a physical demonstration of the laws they had been lectured about and instead opted to create something that went beyond a literal interpretation of physical principles. In other words, for Spangero the notion of force had been the stimulus for their performative response but there was no direct or obvious translation of any of the principles discussed and she would not like the work to be reduced or 'closed' in this way.

The third pair (2 Masters students) constructed a performance space within the studio with chairs and two curtained walls marking the limits. The rules of engagement were then read aloud throughout the time of the presentation. The first of these instructed participants to keep moving at a steady pace. Rule 2 stated that when you touch or are touched by an object or person you should let it move you. Rule number 3 required that when you do make contact you make a sound in reaction. Rule 4 stipulated that now when you make contact you should say yes or no. Rule number 5 elaborated on this idea and stated that when you make contact with the opposite word you are drawn towards them whereas if you make contact with the same word you are repelled. In the final moments participants

were asked to find a way to leave the space before a request was made for every one to look at the space where the action had taken place. Neil Keating, one of the pair responsible for this presentation noted that the scientific approach would have been to take things away; that is, things would have been eliminated in order to isolate a single property or element for observation or examination. By contrast, they had deliberately chosen to add things one by one "to try to get some sort of dynamic balance" (Keating), even when they were aware that earlier instruction might well be forgotten during the later stages of the presentation.

The resulting performative responses were presented and discussion took place as a way of allowing participants to ask questions, discuss their observations or in other ways elaborate on their experience. Project members also offered their own observations and reflections on what they had witnessed.

The second force workshop again took place in the Artaud Building. This time a small group of post graduate engineering students took part in a series of activities that were performance based and although they were based on some of the physics principles given in Smith's original lecture they were not referred to as anything other than exercises designed to generate physical resources for their subsequent work and performances. In other words, the workshop leaders had made a decision to work with a performance vocabulary with engineering students as a counterpoint to the decision to use a conventional physic teaching approach with drama students. The initial activities took several hours, an approach that contrasted with the half hour lecture of the first workshop. This reduced the time students had to work on their performance but gave them a wider range of starting points for the subsequent work. It was felt this was necessary given the fact that these students had little or no experience of performance making. It was also seen to be useful in increasing the students confidence in physicalised performance based activity. The workshop leaders and a project member also participated in the initial activities as a way of reducing fear of judgement in this relatively unfamiliar territory. As Keith Johnstone identified in his influential drama publication *Impro: improvisation and the theatre* (1981: 29-32), a significant challenge in the undertaking of group work is the fear of being judged. This is reiterated in a much more recent article by C Byrge and S Hansen in the European Journal of Engineering Education which is concerned with the development of creativity in interdisciplinary groups:

> "Creativity…involves the courage to leave the automatic responses of stimuli, which are controlled by pattern thinking. In most learning situations…students suffer from fear of not doing the right things in the right way…This is the fear that every person will experience when he/she tries to step out of a pattern of normal behaviour or normal thinking"
>
> (Byrge and Hansen, 2009: 236)

Trust exercises familiar to performance practitioners (Circle drops, Paired drops and Group lifts) were introduced in an attempt to reduce fear and encourage group support of each other. And while there was the customary and expected amount of nerve-driven laughter during a number of these exercises, the students committed to these activities with focus and concentration. Exercises experimenting with balance points of the body and the experience of limits were next. Again students were quick to follow instructions and were largely uninhibited in their responses to requests. The experience of the body subjected to the force of gravity was the primary focus of this fall-based work but this was implicit rather than explicitly referenced. Next the weak forces between objects were introduced via the experience of feeling for the heat between one's palms after vigorously rubbing the hands together. The physics principle implicit in this exercise was that of electromagnetic force. Participants were asked to pair up and then place hands as close as possible to their partner without actually touching. Each participant then explored their own body to find the site of maximum heat emission. An exercise known as Peruvian hypnosis was then used to get students moving through the space and experimenting with force and distance. In pairs, students were asked to place the palm of the hand 30 centimetres from their partner's face. The hand would then lead the face on a journey around the space, all the time maintaining the same distance between face and palm. This exercise was repeated at a distance of a metre and then at 3 metres. At each distance participants had the opportunity of leading and following. In addition, participants were asked about their experience of the exercise at each of the three distances. Participants found the closer the distance the more involved they felt in the process and the more aware of the connection between the two individuals. As distance increased, other factors played a greater role; including awareness of others in the space and the need to try to indicate direction and speed. Again, the implicit rule of force alluded to was; the force of attraction between objects is greater when the distance between them is smaller.

The workshop then shifted to working with large newsprint paper and marker pens. Participants were asked to write sentences that included the word force. This was the first time that force was explicitly mentioned as the thematic concern of the day's activities. The next five minutes produced a range of written responses that were then taped to the wall. The final activity was a drawing task. From the sentences now displayed on the wall, participants were asked to draw a picture or series of images that in some way related to one or more of the sentences. Before the group broke for lunch it was explained that all these materials would form a bank of resources for their performance; that is, they could use any of the ideas, materials or physical actions from the morning's workshop as starting points for their work.

The workshop then moved from the large, cavernous performance space to smaller performance spaces in the upstairs of the building. This was a useful transition and allowed the students to work in a more intimate and less daunting performance environment. It was noted that once the led part of the workshop was completed and the task for the rest of day

explained there was a palpable sense of concern as students wondered how they would proceed with the task. The workshop leaders reiterated that they were available for advice or feedback but made a point of not been present in the rehearsal space for long periods of time to avoid giving students a sense that they were being critically observed by the project members. There was however, a video camera in the room as an observer and the project leader Gretchen Schiller did deliberately intervene to offer words of advice and encouragement to one of the pairs that appeared to remain seated for a protracted part of the performance making process. This stance, observed most clearly in the first workshop with the pair that included the physicist Smith, would appear to be derived from the problem solving model normally adopted by engineers and scientists where a problem is thought through thoroughly and abstractly before any sort of practical activity is proposed. Possible solutions are discussed before committing to any activity in order to more readily identify and eliminate unsuitable proposals and refine those deemed worth pursuing. This clearly has great practical importance in the sphere of engineering where the stakes are higher; 'mistakes' could be costly and there is a clear need to gain a 'right' solution to the problem presented. As Howard Middleton argues, engineers usually deal with problem solving using a "problem space model" (2005: 62) with three parts; a model proposed by Newell and Simon (1972). The first of these is considered the "problem state" which is basically the problem that presents itself in need of 'solving'. From this set of circumstances a "goal state" can be determined, which is a solution to the problem presented. What lies between these two is the "search space" which includes all information and resources that can be called upon to contribute to the resolution of the problem and the achievement of the "goal state". This model assumes that the 'answer' to the problem will be located within the search space and that it is only a process of finding the 'correct'(and usually only) answer, the entire process moving from 'identifying a problem' through 'undertaking research, generating plans for solutions, producing solutions, and evaluating the solutions' (Middleton, 2005: 62). However, what Middleton identifies and what is useful to this project is the acknowledgement that in design and by extension other problem-solving disciplines where the solution is more opaque and harder to define, additional processes and strategies are needed because the solution emerges as a result of "construction" or in the case of these workshops, through practical engagement with workshop partners. Within the discipline of drama, artists and performers may work with ideas in process-based ways; roughly analogous to the search and construction space suggested by Middleton. This space allows the creative exploration of a particular set of circumstances in order to investigate their productive potential for solving a creative problem. This is however a model unfamiliar to our engineering students.

In addition, is the fact that these students are working in an unfamiliar environment, with unfamiliar tools to make a product they are unsure how to construct or value. In other words, great courage was needed to move from the relative safety of a table with pens and paper to the uncertainty and exposure of open space and their own bodies. Once the

mental and physical leaps were taken, the pair were able to move their ideas on from their statically formed imaginings of a performance to a process of examining and discovering additional solutions to the performative challenge chanced upon through the serendipity implicit in practical engagement and the play such action elicits. In other words, the physical experimentation with the ideas conceived abstractly led to a much richer experience and a more nuanced performative response than if the whole thing had been planned and then executed without the physical engagement and play implicit in trying their ideas out practically.

The second pair was heavily led by the older member of the pair and the work roughly worked within a conventional narrative framework that illustrated a range of natural forces at work on the performers. In this respect the work remained within a demonstrative model of performance. This contrasted with the first pair who although slow to get to their feet worked in a more abstract manner with a single concept; forces of attraction and repulsion personified in the students relationship with each other. This appeared a more sophisticated response to the brief. The physics inspired action coming before the additional layer of personal gestures that expressed something of the students' relationship to each other as by turns they repulsed and attracted each other.

Towards some concluding thoughts

Both before and after the workshops, all participants were asked to fill out questionnaires and in addition the engineering post-graduates were interviewed. Here, I focus on the responses of the engineering students. It is clear from the information gathered that the engineering students who took part in the project (and admittedly this is a self selecting group) were open and willing to engage with the tasks asked of them. Some students clearly valued the opportunity to collaborate and expected the activities to be interesting and beneficial. Some expressed the view that they expected to think about their own subject differently and that the workshop would be fun. It was therefore interesting to hear that the engineering students felt that the sorts of activities they had engaged in would really only be useful for undergraduates and that indeed with the strict demands of the curriculum they were unsure how engagements with creativity could be fitted in to the schedule. Perhaps curiously, they all stressed the importance of creativity in the work of the engineer post graduation and in the world of work. In other words they could see its value in certain contexts, but were not willing to really engage with the idea that creativity is something that might be imbedded in the way they worked throughout their development and subsequent career. This is an entirely understandable response but perhaps one that might need rethinking given that any twenty first century graduate is going to need a range of problem-solving strategies to operate in the technically complex, nomadic and transitory working environment where there is a constant need to be adaptable, intellectually dextrous and flexible in one's approach to a wide range of tools, processes and knowledge bases.

Acknowledgements

The author would like to thank the transdisciplinary project team at Brunel University and the Learning and Teaching Development Unit (LTDU) at Brunel for funding the workshops mentioned in this paper. The project team are: Ian Dear, Peter Hobson, Neil Keating, Mary Richards, Gretchen Schiller and David Smith.

Bibliography

Azzam, A.M. E., (2009) 'Why Creativity Now? : A Conversation with Sir Ken Robinson' Teaching for the 21st Century *Educational Leadership*, September , Vol. 67, No. 1, p. 22-26

Byrge C and Hansen, S., (2009) 'The creative platform : a didactic approach for unlimited application of knowledge in interdisciplinary and intercultural groups' *European Journal of Engineering Education,* June, Vol. 34, No. 3, p. 235-250

Johnstone, K., (1981) *Impro: Improvisation and the Theatre,* London, Methuen

Middleton, H., (2005) 'Creative thinking, Values and Design and Technology Education', *International Journal of Technology and Design Education,* Vol. 15, p. 61-71