# Crossing the group-individual divide; brainsketching in design education

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## Abstract

The concept of group brainstorming for idea generation is widely used in business settings; in Ireland it remains underutilised as a pedagogical tool. This study investigated the potential use of individual creative brainstorming; brainsketching in education. A purposive sample was employed comprising of forty-eight students from three secondary (high) schools. The study investigation occurred using two design based tasks (norm and inventory). An intrinsic motivation inventory (IMI) analysed students' motivation for each design based task approach. Brainsketching successfully increased students originality levels of design ideas (r=0.414). In the context of intrinsic motivation, the data demonstrates increased interest/enjoyment (r=0.545), perceived competence (r=0.465) and perceived choice (r=0.063) when using the brainsketching inventory approach. The data suggests brainsketching increased students' levels of intrinsic motivation in the design-based problem solving activity. This indicated the utilisation of a strategic brainsketching approach for creative design based activities in education is conducive to creative idea generation.

## Background

Design involves and requires the ability to carry out many activities[3]. In technology education, design processes are generally advocated for scaffolding design activities. Unfortunately the design processes in education are often prescribed, systematic and linear[6]. In an Irish context, the Department of Education and Science (DES) recommends that "*teachers should give appropriate weighting to students' proper use of the design process before the construction of the artefact*"[7] (p.44). In technology education the 'means' are established, though design is generally practiced through a set of headings to achieve the 'make' goal rather than solving a problem. This is in opposition to many professional design practitioners design thinking and practice. For example, the IDEO approach is a *"system of overlapping spaces rather than a sequence of orderly steps"*[8]. Ad hoc approaches through stages or steps are being implemented, which do not represent holistic design activity. Consequently students creative design practice and abilities are stifled. A prescribed stages approach leads to an assessment driven end goal orientation[5] rather than a design process that guides problem solving promoting exploration for divergent and convergent thinking.

The rhetoric of curriculum advocates the development of student creativity and problem solving capabilities[1]. The development of these capabilities is hampered in schools by the dominance of exam performance. Lee and Todd argue that in the current climate of academic performance does not always include innovation and creativity[2]. Assessment is said to be driving the methodology of teaching[4]. In schools dominated by exam performance, how student's creative problem solving abilities are being nurtured and developed is questionable. It has been highlighted that design is being taught through design projects assessment criteria[2]. Due to assessment criteria and ad hoc approaches to design processes, cognitive and affective processes to achieve creative ideas are not being nurtured. This results in many of the strategies promoting design activity becoming futile, as the method and practice are being neglected[9]. We are subjecting young people to an educational system that assumes one right answer to every question and one correct solution to every problem. This results in a system that does not reward risk taking or learning from mistakes[10]. This ad hoc approach is undermining understanding design practice.

While design activities can invoke thought that is both intuitive and reasoned, higher order discursive strategies enhance the design process. Design activity normally commences due to an identified or defined problem. The design briefs and tasks set by the State Examinations Commission (SEC), Ireland, facilitate divergent thought yet define a specific problem theme to be solved, facilitating convergent thought, both of which are required for creativity. It is essential that students do not fixate on one idea but develop a quantity of ideas early in a design process. However, developing a quantity of unique or progressive ideas is often an issue for many second level students. Though not explicitly stated in the assessment requirements for design based project work, three initial ideas, and after which students identify one idea from their initial ideas and refine this idea prior to realisation, are sought in the assessment process. This inexplicit requirement may limit and stifle idea generation. In this study, the use of individual brainstorming, namely brainsketching, is applied to facilitate and promote creative idea generation in educational based design activities thus develop student's ability to conceptualise and record a quantity of ideas.

**Brainwriting technique Brainsketching**

Brainstorming is a technique for creative problem solving, which was developed and coined by Alex Osborn[11-15]. Rawlinson[14] states that the success of brainstorming depends on Osborn's[11] four central guidelines: 1) no criticism; 2) freewheeling is welcome; 3) quantity and combination are required[11, 13]. In educational environments students often covet their ideas due to concerns for peers copying ideas. Group dynamics play a considerable role in brainstorming. According to Paulus & Brown[17] group brainstorming is generally less effective than individual brainstorming. This issue is primarily due to social loafing[13, 42], where individuals do not exert as much effort in a group setting as they would if working individually. However, Harms et al[18] highlights that group interaction enhances creativity. In this study, to ensure the benefits of group and individual brainstorming are maintained, the silent brainwriting technique was employed; an adaptation of each. It is acknowledged that students are social creatures and enjoy talking, thus this was accommodated in the technique in this study.

Brainwriting is a silent technique, where ideas are written down or sketched making the generation of ideas silent. From an educational perspective there are many different variations of brainwriting[19]. For the purpose of this study, the brainwriting technique, 'brainsketching', was implemented to help scaffold design idea development. It eliminates dominant students leading the session, thus there is less pressure and ideas cannot be shot down, thus allowing the creative juices to flow[19-21]. The power of brainsketching in promoting divergent thinking in successful creative problem solving is evident in a number of studies[24, 2]. In the classroom setting, brainsketching can be used to develop a stimulus of ideas among the students[25]. With idea generation occurring simultaneously, students' concept creativity can be nurtured, as criticism or negative opinions are not facilitated[21]. This strategy should heighten the group exchange process in motivating and facilitating students in the development of innovative solutions[38].

**Methodology**

The aim of this study was to investigate the implementation and evaluation of brainsketching for the generation and promotion of creative design ideas during the 'concept generation' or 'development of design ideas' stage of the design process. The study involved norm (phase one; control) and inventory groups (phase two; experimental). The effect size of the brainsketching strategy was determined from the results of an intrinsic motivation inventory. The strength of the correlation between design ideas and motivation was determined and compared using Spearman's rank correlation (Pearson's correlation coefficient).

***Study participants***

Prior to the study commencement the Institutional Review Board (IRB) Research Ethics Committee approved the study in terms of human participation. All ethical procedures were adhered to in the recruitment and involvement of participants in the study. A purposive sample was employed comprising of forty-eight technology education students from three second level (high school) education institutions; secondary (n=21; 44%), vocational (n=15; 31%), and community (n=12; 25%). There were no issues with apathetic participation or absent students, thus the initial sample size (n=48) and consequent data was included in the analysis. No cases had to be dropped. Using a nonprobability purposive sample, the participants had one year's experience of second level Materials Technology (Wood). This ensured participants had a basic level of knowledge in the relevant subject area to solve the design tasks. The gender breakdown for the sample is comparable to the gender cohort in technology education Ireland[26] (male cohort, n=43; 89.6% and female cohort, n=5; 10.4%).

***Design and structure of research methods***

*Task Details*

The study involved two design based tasks; (a) norm (control) based, and (b) inventory (experimental) based. The briefs challenge students cognitive and affective domains, thus ensuring creativity is facilitated, as it is *"considered both a cognitive and affective endeavour"*[27]. The two design task briefs were selected from the State Examination Commission examination design briefs. This ensured standard and consistency in the problem posed. The briefs selected referenced a similar artefact, though outlined differing themes. The control (a) and experimental (b) briefs implemented entailed;

> Design and make a mirror;
> (a) for bathroom setting to hold personal grooming items with a marine theme,
> (b) for a utility setting to include storage for small personal items to reflect favourite pastime.

*Implementation of Tasks*

The participants were arranged in groups of between four and seven students. All instructions and time guidelines were read aloud to ensure no misconceptions or misunderstanding occurred. All participants commenced the control design based task; phase one. A period subsequent to phase one, all participants commenced the experimental design based task; phase two.

Phase one task involved the traditional (norm) method for solving a design brief. The traditional approach reflects a prescribed product-driven approach rather than a solution-driven approach. A product-driven approach is the common practice in Ireland design-based suite of subjects at second level, where the focus is on the manufacture or realisation of a prescribed product. Data from another study by the author involving undergraduate students of technology education prior experience in project work reflects the dominance of this ad hoc approach with 78% indicating an output-driven approach and 22% indicating a solution-driven approach. In the majority of product-driven 'design' classes a prescribed solution is administered to students via a working drawing. In some cases students are encouraged to brainstorm ideas in a superficial manner. These brainstormed ideas will not be conceived in the manufacturing of the product, unless the student has generated a similar solution to the teacher's prescribed product. As a result, students have little to no input in problem solving conceptual design based activity. For Phase one of this study, students were instructed to brainstorm ideas as per the norm practice.  This consisted of students noting the brief from the whiteboard and generating concepts. The students were not outlined best practices or guidelines for brainstorming. Students were not instructed in terms of how many concepts to generate, though the norm is one to three concepts.

Phase two task involved a strategic brainsketching approach (Figure 3). In order to introduce brainsketching, a warm up activity, 'create a space creature' activity was applied[25], which also prevents entering the technique 'cold'[20]. The warm up activity 'create a space monster' was applied with the experimental group prior to the design task. The brainsketching technique for promoting design ideas was presented via a hand-out, which supported students through the strategic approach (Figure 4).

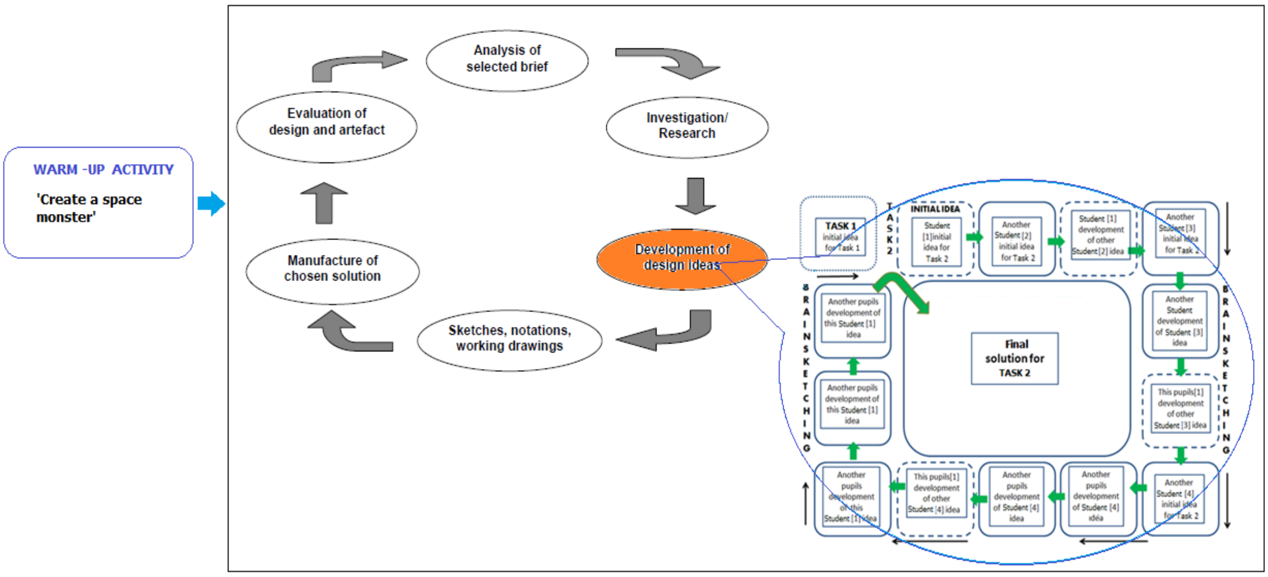


Figure 3: Contextualising the experimental approach

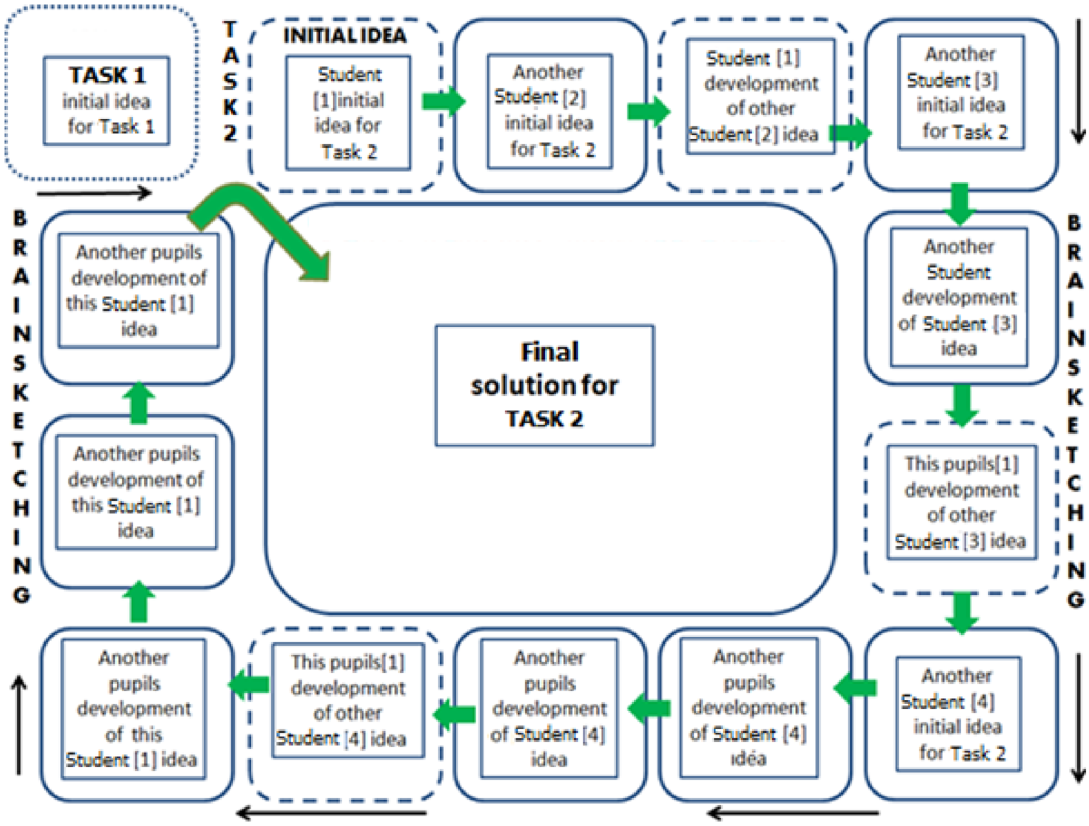

Figure 4: Brainsketching strategic approach

After both tasks (phase one and phase two), students' motivation towards each task was analysed using an intrinsic motivation inventory (IMI)[28]. This consisted of twenty two item scale called the '*Task Evaluation Questionnaire*'.

***Measures***

*Motivation indicating effectiveness*

In this study brainwriting strategy effectiveness was determined with respect to motivation. There are many factors that influence and indicate motivation. One such factor is decision making or perceived choice[28]. Motivation can indicate ones desire and level of participation. In this study, motivation is used as an indicator of effectiveness. It is commonly assumed that motivation influences ones behaviour and performance. Motivation can be related to attitude. Studies have been carried out with respect to teachers' motivation, classroom effectiveness and school improvement[40]. If an individual is in a supportive and conducive environment, this generally results in the individual participating more than expected. Intrinsic motivation indicates that the individual is engaged or driven by internal or personal rewards, rather than external gains or rewards such as a good grade. For this study motivation was determined using the Intrinsic Motivation Inventory (IMI)[28].

The Intrinsic Motivation Inventory (IMI) is a multidimensional measurement device intended to assess participants subjective experience related to a target activity in laboratory experiments. It has been used in several experiments related to intrinsic motivation and self-regulation[43-48]. In the context of the IMI the measures were divided into four sub-scales (a) interest / enjoyment, (b) perceived competence, (c) perceived choice, and (d) pressure/tension[28]. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation; perceived choice and perceived competence are theorised to be positive predictors of both self-report and behavioural measures of intrinsic motivation. The pressure/tension subscale is theorised to be a negative predictor of intrinsic motivation[28]. Students rank from one to seven their motivation towards the control phase one and experimental phase two.

*Originality of design ideas*

The scoring applied to the design tasks for the students design ideas, was in the context of the Torrance and Runco framework[29], which focused on objective and subjective scoring. Originality testing criteria by Torrance[30] applies nine criteria for assessing originality; (a) picturesqueness, (b) vivid, (c) flavour, (d) personal element, (e) original solution, surprising (f) original setting, (g) humour (h) invented word or names, (i) other unusual twist in style. These criteria supported the development of a rubric for assessing the originality of students ideas generated from the design tasks in phase one and phase two. This ensured that scoring was objective using a marking scheme devised with five key headings / criteria; (a) shape, (b) theme, (c) compliance, (d) layout, and (e) multifunctional (Table 1). Under each key heading further criteria were devised to ensure objective assessment. Table 1 illustrates the assessment measures applied; one (1) mark given for criteria achieved, or zero (0) if not achieved or not evident.

Table 1: Originality scoring rubric

| No. | Criteria |
|---|---|
| 1 | Shape<br>• 3D<br>• More than square/rectangle<br>• Curves on design shape |
| 2 | Theme<br>• Theme unique to the person, opposed to everyone having that theme<br>• More than one theme |
| 3 | Brief compliance<br>• Mirror included<br>• Holder for items included<br>• Theme included |
| 4 | Layout<br>• More than a basic shape<br>• Different layout than the common layout for a mirror<br>• Holder for items not just below mirror |
| 5 | Multifunctional<br>• More than the brief asks for<br>• More than a mirror and item holder<br>• More than just a mirror |

## Results

The comparison between the two phases was determined from the scoring rubric outlined in the previous section ‘measures’ (Table 1). The effect size, comparing the two phases, indicates an effect size of r=0.414, which is medium effect[31], equivalent to one grade leap[32]. There is a significant difference between the originality of design ideas between phase one and phase two. From comparing the total originality between phase one (sum=65) and phase two (sum=165) there was a 39.88% difference; indicating the brainsketching inventory greatly promoted design ideas. The mean value for phase one and phase two was 3.095 and 7.762, respectively. The standard deviation for phase one and phase two was 2.21 and 3.82, respectively. The t-test evidenced a p-value of 0.000031, which is less than 0.05 indicating a significant difference between the data sets at 5% the significance level. Thus brainsketching inventory was successful in increasing originality levels of students during idea generation in solving a design brief.

Comparing the originality of design ideas between school-types (Figure 5), the results reflect the school ethos[33]. For example, a vocational schools main focus is the development of practical skills and vocational training. However, the full range of second-level subjects is available. This cohort had a 200% difference between phase one (26.2%) and phase two (12.8%). The secondary school in comparison is traditionally more of an ‘academic’ education, though in recent years they have introduced practical and technical subjects. This cohort had the lowest originality levels overall but achieved the second greatest difference (308%) between phase one (6.7%) and phase two (20.5%). The greatest difference (371%) in originality between phase one (7.2%) and phase two (26.7%) was evident for the community school, which were set up to give recognition to a compromise between secondary and vocational Schools, offering a broad curriculum embracing both practical and academic subjects.

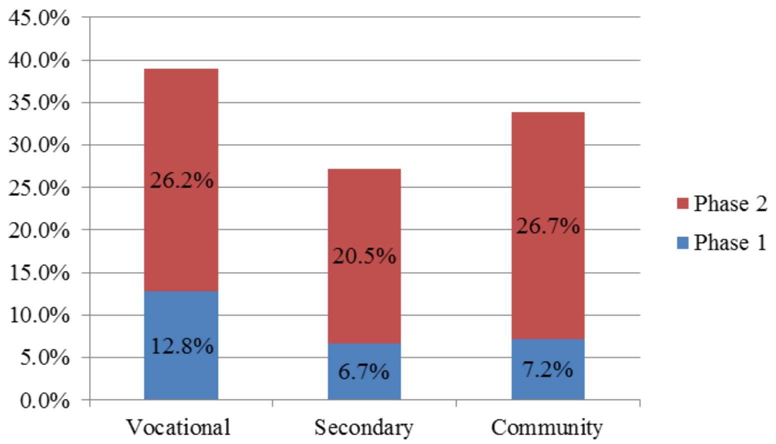


Figure 5: Originality of design ideas between school types

The following section explores the level of students intrinsic motivation between phase one and phase two. The hypothesis under analysis; increase in design ideas (due to the brainsketching strategy) due to an increase in motivation.

***Intrinsic motivation***

In the context of intrinsic motivation, the IMI data suggests during the initial stages of the design process, brainsketching has a small effect size (r=0.142)[31]. Comparing the IMI mean scores (phase one; 8.038, phase two; 8.251), this evidences an increase in students’ levels of intrinsic motivation in design based problem solving activity. The IMI standard deviation for phase one and phase two was 0.84 and 0.92, respectively. From the t-test, statistically there is no significant difference (p-value 0.0948) between phase one and phase two in terms of intrinsic motivation levels. The rationale for this could be due to the similarity in brief type rather than the strategic approach to achieve the design based task.

Further exploring the sub-scales for intrinsic motivation, the impact of the brainsketching inventory is statistically different in all but one of the IMI sub-scales (p-value < 0.05) (Table 2). One of the sub-scales ‘pressure / tension’ there is no statistical difference with a p-value of 0.759. As students could not select or create the design brief, this sub-scale was ignored. In addition, there was no assessment focus thus reducing the ‘pressure-tension’ aspect. The effect size of intrinsic motivation between phases one and two ranges between small (0.063) to medium (0.544, 0.465). The results evidence an increase in originality of design ideas and an intrinsic motivation to do so. This supports Hennessey and Amabile’s (1987) principle that intrinsic motivation contributes to creativity and extrinsic motivation can hinder creativity[34]. Thus highlights the positive impact of the brainsketching strategic approach during phase two of this study.

Table 2: IMI sub-scale results

| | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 | Phase 1 | Phase 2 |
|---|---|---|---|---|---|---|---|---|
| Sub scales: | Interest/Enjoyment | | Perceived Competence | | Perceived Choice | | Pressure Tension | |
| Mean | 2.45 | 2.68 | 2.08 | 2.27 | 1.93 | 1.96 | 1.59 | 1.34 |
| St. Dev | .43 | .41 | .42 | .40 | .46 | .47 | .55 | .38 |
| TTEST (p value) | 0.00696 | | 0.01114 | | 0.0219 | | 0.759 | |
| Significance | Difference | | Difference | | Difference | | No Difference | |
| Effect size | 0.544588 | | 0.465 | | 0.063 | | 0.515 | |

The participants’ responses reinforced the satisfaction with the brainsketching strategic approach. According to one participant the activity *“gave more inspiration about what to draw and that everyone has great unique ideas”* (Participant A, CS). Another participant outlined that receiving another participants’ opinion helped *“other people might see something on my project that I might not see, this could improve the project”* (Participant 33, CS). This appreciation, for the use of a design activity and also collaborating with other participants in the class group with a view to improving their ideas was very positive.

In the context of correlating total design ideas and total intrinsic motivation, Spearman’s coefficient correlation (Pearson’s correlation) was determined (r=-0.285). The strength of association is small, indicating that the correlation between design ideas and intrinsic motivation is small. The negative value suggests that the more design ideas the lower the intrinsic motivation. This is suggestive that more design ideas results in student’s intrinsic motivation decreasing. This is suggestive of the focus by students, such as fixation, on one idea or craft (realisation/manufacture) focus in the subject.

**Discussion**

The aim of this study was to investigate students design idea development through the use of a brainsketching approach during conceptual design activities in technology education. As intrinsic motivation is a principle of creativity, evidence of such was sought and evidenced in this context via originality of design ideas. In the context of this study many variables were analysed. Though intrinsic motivation and design ideas did not correlate, there was an increase in originality levels of design ideas.

In spite of the tool of brainstorming having some critics[35, 36], brainsketching has been proven successful in the context of technology education design based activity; design idea generation. The results show a significant statistical difference (p-value=0.0000311) between phase one (mean value = 3.095) and phase two (mean value = 7.76), which highlight the effectiveness of the strategic approach of brainsketching in an educational context. In addition, differences in intrinsic motivation from design activities such as brainsketching re-emphasise the value of activities, which get all students engaged and intrinsically motivated. The Organisation for Economic Co-operation and Development (OECD) report (2000) highlighted activities which involve project-based learning "*intrinsic motivation can be enhanced by project-based learning, which enables small groups of students to work together on extended exercises*"[38] (p.31).

In this study, brainsketching is evidenced as a tool for promoting divergent thinking in the context of technology education. This finding correlates with findings of Kohn, et al., which evidences the impact of a group exchange process in motivating and facilitating students in the development of innovative solutions[39]. This is proven in this research study with an increase in originality by approximately 40% between phase one and phase two.

The importance of collaboration has been highlighted as a useful tool by Einstein, Heisenberg, Pauli and Bohr's breakthroughs using collaborative thinking[20] (Michalko, 2001). The use of the brainsketching strategic approach during a design based activity provided the cohort (n=48) a systematic approach and confidence in designing by providing a setting for lateral thinking and cross stimulus of ideas to occur[25]. In this study as participants' ideas were continually improving and evolving self-efficacy[23] was nurtured, which is important in terms of self-competence in creative problem solving.

## Conclusion

A diverse range of design strategies should be applied in technology education to promote students' motivation to become more accomplished and effective thinkers and problem solvers. The use of a strategic approach during design activity to increase students' motivation towards the initial conceptual stages of the design process has been proven with increased originality and IMI values between phase one and phase two.

The limiting factors, such as social loafing[40] often associated with typical brainstorming sessions, were not evident which could be due to the use of brainsketching in phase two. As a result this reduces pressure and anxiety (which limit creativity) consequently nurturing student's innate idea generation abilities in an inclusive environment. Motivation, creativity and higher order thinking were stimulated by the authentic learning task, brainsketching, in an educational setting[41].

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