Creativity and the design approach: a proposed module

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Creativity and the design approach: a proposed module

Naomi Klein and Yaacov Shragai
Braude College, Karmiel, Israel

Abstract

Can young students be taught to think creatively? Can everyone be creative? The study examined the effect of infusing creativity into science and technology curriculum (ICSTC) on students’ creativity and on implementation of creativity, using the ‘design approach’. Differences in effects on genders were also examined. The module was taught one semester, two hours a week. There were 149 participants, 69 boys and 80 girls, 14 years of age, that formed the experimental and the control group.

The tools used were:

- ICSTC module and booklet
- a creativity questionnaire
- the TACT (Tel-Aviv Creativity Test)
- a special science implementing test
- performance assessment
- students’ interviews and class observation.

Results show that:

- creativity was enhanced significantly. The girls’ creativity was enhanced more than the boys’ creativity.
- creative boys implement creativity thinking skills in science better than creative girls do.

Suggestions are made about the implications of these results for educational practice.

Keywords: creativity, gender, science and technology, design approach, infusion, performance assessment

The question of whether creativity can be enhanced and the nature of educational programs to develop or encourage creativity has been dealt with over the years (Dewey, 1933; Isaksen and Parres, 1985; Wallas, 1926), and is the focus of this paper.

The purpose of this study was to investigate the hypothesis that a science and technology 12-week intervention program, which included facilitating the creative thinking skills of children, in an inquiry-based curriculum, with real-world applications, would produce a higher level of creativity and creative implementing capabilities for boys and girls.

This study deals with the design of the module Infusing Creativity into Science and Technology Curriculum (ICSTC). The module includes the rationale, principles of working in the class, principles of teachers’ reactions, and implementation of the module. The module has been implemented in an integrated workshop for pre-service and in-service teachers and in eighth grade of junior high.

The research questions guiding this study were:

- is there a difference between creativity scores of students who took the ICSTC module and between scores of students who did not take it?
- is there a difference between creativity scores of boys and girls who took the ICSTC module?
- are there differences in application of creativity between students who took the ICSTC module and between those who did not take it?
is there correlation between creativity scores (of the creativity test) and between application of creativity, for students who took the ICSTC module?

is there a difference in correlation of creativity scores (of the creativity test) and application of creativity, for boys and girls who took the ICSTC module?

Teaching creative thinking skills

What is creativity?

What is creativity and what is it about creativity that elicits so much curiosity? Literature reveals that creativity is many things, it is a way of looking at the world and a way of opening up avenues to opportunity, adventure, and self-confidence (Adams-Price, 1998; Guilford, 1967; Perkins and Swartz, 1992). Research stemming from cognitive psychology considers creativity as an ability that is subjected to changes in the course of a person’s life, and is based on different intellectual skills, each skill points to a different functioning of the mind (Guilford, 1967). Isaksen (1987: 8) noted that creativity occurs in many people, in differing degrees and manners, and should be viewed as ‘a multi-faceted phenomenon rather than as a single unitary construct capable of precise definition’. Gardner (1997: 5) observes that there is no ‘absolute divide’ between the ordinary and the extraordinary; we all harbor within us creative seeds that are capable of flourishing. This leads to the conclusion that everyone can be creative and everyone’s creativity can be enhanced through an educational interference (Guilford, 1967).

Researchers stress the importance of insight and the ‘aha’ experience where a solution suddenly emerges after a period of preparation and incubation. (Houtz and Frankel, 1992; Wallas, 1926). Others see creative thought as a directed, controlled phenomenon that is only quantitatively different from everyday thinking, and ultimately depends on the active manipulation of available information using mechanisms such as analogical reasoning (Sternberg and Lubart, 1991).

Recognising creative thinking as being described by different dimensions led to three developments. The first development associates creativity with a systematic process (Goldenberg, Mazursky and Solomon, 1999), a process that involves reorganising of known components and manipulating them systematically, resulting in believing that creativity can be taught and enhanced (Sternberg, 1988; Sternberg and Lubart, 1991). The second development deals with developing tests for assessing creative ability. The third development deals with techniques in teaching creativity such as brain storming for enhancing divergent thinking and thinking of the alternatives (lateral thinking) for breaking thinking barriers (De-Bono, 1973), which are recommended by educators (De-Bono, 1973; Rodd, 1999).

As has been discussed above, the question of ‘Who is creative?’ does not have a straightforward answer. If someone is asked: ‘Who is a football player?’ then the answer will probably be: ‘The one who plays by the rules of the football game’. But what are the rules of creativity if it is concerned with surprise and inspiration?

Assessment of creativity involves two principles.

1. It is important to consider information derived from multiple sources such as parents, teachers, self-ratings, performance assessments, and teacher observations.

2. Ample opportunities should be provided for creative behaviours to emerge, to be observed and to be considered in determining children’s potential for creative productivity.

(Ohio Department of Education, 1992; Fishkin and Johnson, 1998; Runco, 1993)

Teaching creativity

The answer to the question: ‘How to teach creativity’ was dealt by Torrance (1969), who suggested two main directions:

1. creating encouraging conditions of open with no criticising atmosphere

2. introducing activities that motivate and activate the learning process, e.g. confrontation with ambiguities, heightened anticipation, looking at the same thing from several different viewpoints, prediction.

This research deals with teaching creativity and looking for ways to enhance it for boys and girls and the question of whether there are differences between the genders in regard to creativity and its application, is dealt with here. Literature reveals different and contradictory findings concerning the issue of creativity and gender. Nevo and Levine (1978) found no significant differences between the genders in creativity. Pohlman,
The design approach relates to a teaching strategy and essentially involves three stages, i.e. analysis, synthesis, and evaluation (Sternberg, 1988b). This approach is based on students’ needs to learn to identify and solve real problems in authentic situations, and the recognition that relevancy of information to the personal lives of students is an important aspect of teaching (Perkins and Swartz, 1992). The projects that emerge provide means for putting knowledge and skills into practice and facilitate the development of higher order analysis, synthesis and evaluation skills. It concentrates on using sets of established principles and practices within certain constraints, such as cost, appearance, to accomplish an intended purpose. These experiences have tremendous potential for capturing

**Infusing**

The concept of infusing the teaching of creativity into the teaching of subject matter and incorporating it across the curriculum (Rodd, 1999) was accelerated mainly in the last decade. By infusing, knowledge would go hand in hand with thinking and relevancy and application (Dewey, 1933; Perkins and Swartz, 1992). Swartz and Parks (1992) claim that infusion enhances the students thinking skills and enhances learning the content of the subject matter.

<table>
<thead>
<tr>
<th>Session Subjects No.</th>
<th>Class Activities</th>
<th>Student/Group Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Creative thinking</td>
<td>Creative thinking exercises</td>
<td>Creative thinking exercises</td>
</tr>
<tr>
<td>2 STAGE 1: the design process</td>
<td>Explaining the process</td>
<td>Group discussion following introduction of a case</td>
</tr>
<tr>
<td></td>
<td>Defining: need, problem, demand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class discussion based on group reporting</td>
<td></td>
</tr>
<tr>
<td>3 Preparation for writing the portfolio</td>
<td>Discussing examples generated at home.</td>
<td>Group decision: choosing the subject</td>
</tr>
<tr>
<td></td>
<td>Presenting the design process and time-table</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Developing criteria for evaluation</td>
<td></td>
</tr>
<tr>
<td>4 Creative thinking</td>
<td>Creative thinking exercises</td>
<td>Creative thinking exercises</td>
</tr>
<tr>
<td>5 STAGE 2: exploring STAGE 3: brainstorming</td>
<td>Class discussion: gathering information (sources, classification)</td>
<td>Brain storming: gathering information for the chosen subject, classifying, organising Planning solution</td>
</tr>
<tr>
<td>6 STAGE 4: choosing the group solution</td>
<td></td>
<td>Evaluating different solutions Choosing the ‘best’ solution</td>
</tr>
<tr>
<td>7 STAGE 5: developing the final plan</td>
<td></td>
<td>Draw prototype in scale List of instrument and materials Verifying all information</td>
</tr>
<tr>
<td>8–9 Building prototype</td>
<td></td>
<td>Building prototype Documenting (portfolio)</td>
</tr>
<tr>
<td>10 Evaluation Handing in</td>
<td>Discussion, presenting prototypes Handing in portfolios and prototypes</td>
<td>Discussing and evaluating group-mates</td>
</tr>
<tr>
<td>11-12 Group summaries</td>
<td>Preparing for school exhibition</td>
<td>Relating to evaluating group-mates</td>
</tr>
</tbody>
</table>

*Table 1: The ICSTC module – subjects, activities and timetable.*
Although the parameters of topics suitable for independent student research can be virtually unlimited, students should clearly outline and implement the research methodology. They may find research topics by brainstorming what they are interested in, then further brainstorming what they would like to know and where they might find the necessary information. Before and between these brainstorming activities, for four hours, enrichment activities such as problem solving, lateral thinking, synectics are woven, which are structured to help students develop their creative thinking skills. Assessing creativity, particularly in the subjects of thinking skills and implementation, is acquired by several means. One illustration of the design project concerns creating a prototype on an aiding surrounding for a sick student who is restrained to his bed for some time to address the needs of the student. Another illustration is creating a prototype of dog feeding apparatus, taking into consideration his size, how he is built, his needs and eating habits.

Creativity test

The creativity test, the TACT (Tel Aviv Creativity Test), a battery of divergent thinking, is a Hebrew adaptation by R.M. Milgram, of the Wallach and Kogan creativity battery. This is a well-validated, reliable test, recognised all over the world, and widely used. This battery contains four kinds of tests: alternative use (AU) (4 items), pattern meanings (PM) (4 items), similarities (S) (3 items), and line meanings (LM) (4 items), 15 items altogether. The AU and the S subsets stimulate verbally and the other two subsets are shape stimuli. The responses to each item of the subset were graded on two dimensions of creative thinking: ideational fluency (the number of discrete responses) and uniqueness of ideas (‘remote responses’, the manual’s

<table>
<thead>
<tr>
<th>Item</th>
<th>Obvious response</th>
<th>Remote response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nails in a wooden board.</td>
<td>Raindrops or five worms moving.</td>
</tr>
<tr>
<td>2</td>
<td>Hills.</td>
<td>Folded paper.</td>
</tr>
</tbody>
</table>

Figure 1.

Participants

Participants were 149 eighth grade Israeli students (14 years of age, with age mean of 14.2) of a medium social economic level. The experimental group consisted of 107 students (60 girls and 47 boys), from six classes of three comprehensive schools (half of each class). Each class was divided randomly into two groups by the school management. One group of each class was assigned the ICSTC module, forming the whole experimental group. The control group consists of 42 students (20 girls and 22 boys), three out of the remaining six half classes. The academic balance in each class is about the same, according to score mean of the taught subjects of each class of the recent semester.

Instrument and procedures

ICSTC module and booklet

The module, the ICSTC (Infusing Creativity into Science and Technology Curriculum), which lasts 12 two-hour lessons, expresses several dimensions of creativity such as sensitivity to problems, making guesses, formulating hypotheses; evaluating and testing; and communicating results working autonomously, curiosity, unconventional thinking, openness to experience, and tolerance of ambiguity (Torrance, 1969; Adams-Price, 1998). Table 1 presents the module’s timetable according to subjects and activities.
A reliability analysis for the science-implementing test was conducted, revealing moderate values.

**Performance assessment**

This was achieved by the teachers’ assessing of the ICSTC products, as recommended in situations where students have generated complex and varied responses to real world tasks (Runco, 1993). Their methods of rating the creative products use three clearly defined criteria: novelty, resolution of the problem to be solved, and synthesis/evaluation.

**A semi-structured interview**

The interview, with open-ended questions, was used to generate personal responses on the issue of learning with the ICSTC module. Thirteen students were chosen randomly and were interviewed by one of the researchers, for about 20 minutes each. The students were asked to describe their project and to relate to class activities.

**Class observation**

Observations of student behaviours during the intervention program were performed by two judges and were video taped. The observation sessions took place in a random fashion, rotating between the classes. The observers focused on the students’ involvement with their peers and participation in the class activities. No criterion-referenced list was provided.

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**The science-implementing test**

The purpose of the test, written for this research, is to evaluate whether there has been a transfer of learned capabilities from teaching the module. The construction of the science-implementing test is based on the Problem Solving Taxonomy (PST), and is based on Routine, Diagnosis, Strategy, Interpretation and Generation (Plants et al., 1980).

The science-implementing test includes 10 questions; each question consists of three parts, and each part is marked separately. The first part tests knowledge and understanding and scored as Mark A. The second part tests interpretation and scored as Mark B. In the third part the student is asked to come up with an original question, and is scored as Mark C. An example for a question of the science-implementing test is provided in Figure 2 (Part A corresponds to Mark A and so on).

Question no. 2 of the science-implementing test.

**Part A:** The figure above contains four separate closed electric circuits. Lamp 1 is switched on. In which of these circuits are the other three lamps switched off? Explain.

![Figure 2](image)

**Part B:** Suppose that you have a storage battery and four lamps. How would you build a circuit that operates in the following way: when lamps no. 1 and no. 2 are switched on, lamps no. 3 and no. 4 are still switched on.

**Part C:** Think of an original and interesting question, which deals with the same subject. Please write it down and answer it.
Procedure

The study began with writing and revising the ICSTC module to fit the framework of age (14) and time interval (one semester) for the proposed participants, followed by exposing the teachers involved to the new module by participating in a workshop. After taking the creativity pretest, the experimental group was exposed to the module for 12 two-hour weekly meeting, during which the students’ activities in the class were observed randomly. The creative thinking skills were presented and practiced mainly during the second and third week. Upon completion, the creativity and science-implementing tests were administered to all students; 12 students of the experimental group were interviewed. The science-implementing test was administered only at the end of the intervention. All the students took a natural science course at the same semester. This mix method is based on using the quantitative and the qualitative means, thus enables the use of triangulation and elaboration of data and provides insight into the effectiveness of the intervention program on student’s creativity.

Results

To address the first research question of this study (‘Is there a difference between creativity scores of students who took the ICSTC module and between scores of students who did not take it?’), a paired sample t-test, was conducted with the pre-test and post-test scores of the creativity test. The students (N = 107) of the experimental group’s mean score was 46.85 (SD = 17.46) on the creativity pretest and 55.77 (SD = 20.00) on the creativity post-test. The t-test yielded a t (86) of 4.23, which was statistically significant with p < .001. The effect size was 0.51, which is considered high. The results indicated that no significant differences were found between pre-test creativity scores of the experimental group and those of the control group and no significant changes between pre-test and post-test scores of the control group.

For the second research question (‘Is there a difference between creativity scores of boys and girls who took the ICSTC module?’ a paired sample t-test was conducted with the pre-test and post-test scores of the creativity test. Girls (N = 51) had a mean of 49.25 (SD = 18.33) on the pre-test and a mean of 59.51 (SD = 20.89) on the post-test. The t-test yielded at (51) of 4.24, which was statistically significant, with p < .005 and effect size of .56. Table 2 compares the pre and post measures for boys and for girls. A paired sample t-test indicated that the girls’ post-test scores were significantly higher than the girls’ pre-test mean scores regarding the four subsets and the overall questionnaire, with a moderate to high effect size. The results show no significant changes for the boys.

The third research question was ‘Are there differences in application of creativity between students who took the ICSTC module and between those who did not take it?’ Because of last minute changes in the students’ schedule, not all the students of the experimental group and of the control group took this test. The science-implementing test consisted of three parts. A Friedman test for non-parametric groups (the scores were not normally distributed) conducted with the three parts’ scores were significantly different, suggesting that each part tests a different dimension, where mark A is knowledge based, mark B is Interpretation based and mark C is creative implementation based. Therefore data about mark C should give an answer to the question.

In order to compare the experimental group scores and the control group scores, a Mann Whitney test (scores were not normally distributed) for independent-samples was conducted, revealing no statistically significant differences between experimental group and of the control group for each of the three marks. The experimental group (N = 24) had a mean of 48.25 (SD = 12.31) on mark A, a mean of 28.08 (SD = 9.25) on mark B, a mean of 16.53 (SD = 8.52) on mark C. The control group (N = 26) had a mean of 46.62 (SD = 11.54) on mark A, a mean of 30.85 (SD = 10.98) on mark B, a mean of 15.69 (SD = 12.05) on mark C.

To address the fourth research question ‘Is there correlation between creativity scores (of the creativity test) and between application of creativity, for students who took the ICSTC module?’ correlation between pre-test and post-test creativity scores and between mark C was conducted. The results indicated that only the correlation between mark C of the science-implementing test and the total post-test scores of the creativity questionnaire for the experimental group was high (r = .518) and statistically significant at the .01 level. The results suggest that if a student of the experimental group scored high on mark C, which is creative implementation based, he may score high on the post-test creativity questionnaire.
Gardner (1997) describes the creative individual as one who regularly solves problems, fashions products, or defines new questions in a way initially considered novel but ultimately accepted as integral to that domain. This is the foundation for the science and technology intervention program, developed for this research study.

Statistical significance was evident for the girls’ gain on measures of creative thinking skills and all four parts, while literature provides various studies with contradicting results regarding genders’ creativity differences.

The data regarding girls statistically significant gain and the boys’ high correlation between creativity and application of creativity in science brings up a question regarding the differences between the genders: why were the girls with high creativity not able to apply creativity in science, as did the boys with high creativity? These findings are suspected to be the results of something that may have held back the girls from applying creativity. Could it be their social environment or stereotype (Solomon, 1997) or differential opportunities with hands on activities (Kerka, 1993).

The class atmosphere was very supportive, especially for the girls, this complies with Kerka’s (1993) stating that achieving is generally characterised for women to be linked to relationships, cooperation, and intimacy rather than competition. The writers believe that the exposure to the inventive atmosphere, dealing with different aspects of science and technology would cause science and technology to come more easily and naturally to the girls, and may bring girls closer to the subject of science, resulting in motivating more girls to study science and technology. Therefore this module, could act as a leverage, making the girls aware of their creative skills and helping them apply creativity in science.

The results of this study add further support to the basic understanding that is rooted in the designing of this study, namely every one can be creative (Guilford, 1967; Isaksen, 1987) and there are means to enhance creativity (Isaksen and Parres, 1985; Sternberg, 1988; Sternberg and Lubart, 1991). The module may serve as a platform to narrow the gap between the genders in considering science to be the subject of their future learning and involvement. It can be practiced also in case of infusing creativity into other subject-matters.

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