Are we educating to promote students' creative capacities?: A study in Technology Education in Ireland

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Abstract

This paper focuses on student's creative capacity, in terms of natural creative tendencies, in the three levels of education; primary (first), second, and third level. Creative capacity was investigated through a comparative analysis of creativity quotient (CQ).

Two hundred and four pupils participated in this research study, in the location of their everyday classroom / laboratory environment. Participants were assessed in terms of creative quotient (CQ) derived from fluency and flexibility values. From analysis of the mean data, third level students proved the most creative in the context of creative quotient. However, further comparative analysis occurred in terms of the statistical difference (p-value) for fluency, flexibility and CQ in the context of the three educational institutions. Overall, there is a small difference (very small effect size <0.1) between primary and second level, and primary and third level, in the context of fluency, flexibility, and CQ. In terms of second and third level, in the context of fluency, flexibility and CQ, there was no difference. It is necessary that creativity is promoted throughout our education systems to ensure pupils maintain and develop their creative capacities into adulthood. A young child may have the capacity to be creative, but as they get older, if they do not have the need to be creative, their capacity may fade. Later in life they may struggle to reconnect to the creativity they had during their youth. Education systems need to foster independent thinking, creativity and innovation. This paper portrays student's creative capacity in technology education spanning from early years through to upper secondary education and teacher education in the context of fluency, flexibility and creativity quotient.

Technology Education in Ireland

According to the Irish Central Statistics Office, 2011 census, preliminary results, Ireland has a population of approximately 4,581,269 (CSO, 2012). First, second and third level education caters for approximately 509,652, 356,107 and 161,647 students, respectively, distributed in 3,165, 750 and 33 institutions respectively. In an Irish context, first level does not have a compulsory technology education subject in the curriculum (DES, 1971; DES, 1999; NCCA, 1993). The age of primary level students ranges from approximately 4 to 12 years of age.

Second level education is divided into two main cycles; junior and senior (NCCA, 2012). The age of junior cycle students ranges approximately from 12 years old to 15 years old. Students study a minimum of eight subjects in junior cycle, of which the technology education suite of subjects is optional. Senior cycle student's age ranges approximately from 15 to 18 years of age. Students must study a minimum of five subjects in senior cycle, however to achieve entry to third level a minimum of six subjects must be undertaken. The Irish third level 'points system' has a benchmark of 600 points. Senior cycle subjects are divided into subject departments, and once again the technology education suite of subjects is optional.

Third level education is optional, but approximately fifty percent of second level students advance from second level to third level, depending on socio-economic factors and entry points. In Ireland, there are three main third level educational institutions; university, institute of technology, and teacher training.

In relation to the three levels of education in Ireland, the primary aim is to enable individuals "to realise their potential as individuals and to live their lives to the fullest capacity appropriate to their particular stage of development" (DES, 2012; DES, 2004). The aim of this study is to investigate pupil's creative capacities through creativity quotient, in Irish education systems; primary, second and third level.

Creativity expectations at the levels of education

Scientifically defining creativity is broad and context specific. Creativity, normally a right brain operation, is often stifled due to the dominance of the '3R's' (reading, writing and arithmetic), normally a left brain operation, in the current education system. Creativity can be nurtured in Technology education by "*building a responsive environment in which there is an atmosphere of receptive learning*" (Atkinson, 1994). Everybody has the capacity to be creative (Robinson, 2001). Robinson also argues that as individuals, we do not grow into creativity; we grow out of creativity (Robinson, 2001). In relation to fear, Sternberg (2006) notes that fear can act as a blockage and risk taking is necessary to produce something creative when he states that "*creativity is in large part a decision that anyone can make but few people actually do make because they find the costs to be too high*" (Sternberg 2006, p. 97).

Creativity is a term that is often used in education, but is rarely defined. Creativity researchers generally agree that creativity involves a combination of uniqueness and usefulness (Beghetto, 2005). In an extensive content analysis of creativity articles by Plucker, Beghetto & Dow (2004) it was discovered that "*clear definitions of creativity are rarely consistent, if offered at all*" (Plucker, Beghetto & Dow, 2004, p.88). Their analysis proved that the most common characteristics of explicit definitions for creativity were uniqueness (n = 24) and usefulness (n= 17) and of the ninety articles selected two articles used the term over one hundred times without defining it. Creativity involves the contribution of unique/original and useful ideas in any given situation. It was proposed that creativity is the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context (Plucker, Beghetto & Dow 2004, p. 90). Products that are novel but have no use or merit or significance are simply novel, not creative. Likewise, products that are useful but are not novel, unique, or original are simply useful, not creative (Beghetto, 2005). For the purpose of this study, the above definition for creativity, proposed by Plucker, Beghetto & Dow (2004) was used as the assessment criteria for the creative abilities of the participants.

It is important to take into account the social context, the level of the students' creativity in the three levels of education, which were assessed using the specifications of the contextual parameters. Plucker, Beghetto & Dow, (2004) stated; "*a particular 4th grade science project is creative in the context of fourth graders...at the same time, specifying context does not allow for empty realistic claims that a 4th grade science project necessarily is as creative or significant as a Nobel – Prize winning discovery*" (Plucker, Beghetto & Dow, 2004, p. 92). Hence, each level of education is seen as creative in the context of their own environment. Hennessey & Amabile, (1988, cited by Beattie, 2000) sup-

port this view when they suggest that, judges should rate creative products relative to one another, rather than to some absolute standard of creativity for the domain. Assessing creativity within a social context is important as primary level students may not have the skills to adequately express or fully communicate a unique idea in comparison to a third level student (Fishkin & Johnson 1998).

Instruments for measuring Creativity

To ensure an accurate measurement of creativity, the use of the creativity quotient was applied, which accounts for the number of ideas (fluency) and the number of distinct categories the ideas fall into (flexibility). The CQ can be represented mathematically as CQ = 1.44 ln (u+1) (Synder et al, 2004). The product (u+1) was calculated by determining the number of categories and uses within each category. This is represented in the formula $(1+u_1)(1+u_2)(1+u_3)$, where u_1, u_2, u_3 respectively are the number of uses student proposes in each category respectively. If no answer is given in a category then u=0 (Snyder et al, 2004). From each participant response, CQ, is calculated using the product number combinations to the logarithm base 2, usually used in information theory; CQ = $\log_2 [(1+u_1)(1+u_2)(1+u_3)....(1+u_c)]$

Methodology

To achieve the aim of this study, students' participated in a creativity thinking task developed by Sternberg (Sternberg, 1999, Runco, 2001).

Selection of Participants

This study comprised of a representational sample of the three levels of education systems in Ireland (Drudy and Lynch, 1993) (Lynch and Lodge, 2005). The students in second and third level are students from Technology education. This subject area does not exist in primary education. Class teachers were not involved in the implementation of the testing. The developer carried out all research activities to reduce external influencing factors on participant's creativity (Fishkin & Johnson, 1998). The participants from primary and secondary level were chosen from the final year of their respective level of education. This was decided as it would represent the output or product from this level of education. Undergraduates in the third level are training teachers for the 'Technology education' second level suite of subjects in Ireland.

Characteristics of participants

Primary school participant's ages ranged from eleven to thirteen years, while second level participants ages ranged between seventeen and nineteen years. Third level student's ages ranged from nineteen to thirty-three years. The number breakdown of participants from primary, secondary and third level in this study was 78, 72, and 54 respectively. A limitation of this study may be the 'assessment driven' nature of education, which could stifle student's creativity. This is also highlighted by Sternberg; for many individuals, not having the need to be creative has been masked by a society that encourages knowledge conformity (Sternberg, 2009). While there are differences across the levels of education in terms of knowledge and skills in terms of what is required and expected of them in school; however creativity is a skill which is an outcome required from all three levels; the ability to think laterally. This study investigates the natural tendencies of participants across the three levels of education.

Design & Structure of Research Tools

The creative thinking test was designed following extensive consultation of literature on creativity. One of the most popular and most respected methods of measuring creative ability is Guilford's paper-and-pencil, Alternate Uses Test, in which test takers are asked to list as many uses for a common object (e.g., a tin can, or a brick) as possible. Creative ability or divergent thinking tests, such as Guilford's Alternate Uses test, can provide a good prediction of a person's creative performance (Plucker & Renzulli, 1999; Runco, 2007). For this study, the test used made it possible to quan-

tify creative ability and to compare individuals on a "standard" scale (Sternberg & Lubart, 1999). Questions one, two and three were based on divergent thinking tests (Sternberg, 1999). Though divergent thinking ability is not akin to creative ability, it is suggestive of the possibility for creative performance (Runco, 2001). These three questions were open-ended answer questions that allowed pupils to respond with as many answers as they could devise, within the given time (Figure 1). These open-ended questions are theoretically and empirically related to everyday creativity (Runco, 2001), by allowing participants to divergently think in an unrestrictive fun environment, generating as many different possibilities for a given problem (Kozbelt, Beghetto, Runco, 2010). While divergent thinking is not equivalent to creative thinking, it measures creativity through divergent thinking. Another question can be raised in terms of how you classify a students' response in relation to creative or knowledgeable. Thus the reason for introducing the creativity tasks as 'game like' or fun, to reduce the focus on knowledge (Villalba, 2008).

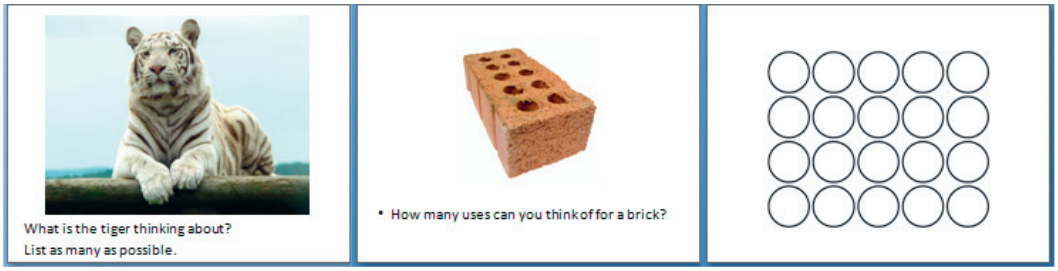

Figure 1: Creativity task, questions 1-3.

Timing of Creativity Tests

Wallach and Kogan (1965) showed that the intelligence–creativity relationship is strongly dependent on the degree of speed of test tasks. This refers to the extent to which time constrains are put on a test. For this study the importance of non speeded assessment conditions in creating a non-evaluative, game-like environment, is a necessary condition for creativity assessment (Kogan, 2008). However, in order to complete a standard task for all participants, timing constraints had to be implemented. Although a limitation to the study, this is an unavoidable consequence of ensuring standardisation across the levels of education.

Therefore research was needed to identify the time constraints applied for the tasks. Wallach and Kogan (1965) discuss that the first two minutes of the task, students are at their least creative, therefore, this study decided to allow more time. For the creativity task, each participant was given equal amount of time to record their answers; 3 minutes 45 seconds. One at a time, the questions were presented on PowerPoint or overheads, depending on school's resources. There was no respective difference in the quality of questions presented. The author gave the same prompts and examples to every class group (Fishkin & Johnson, 1998).

Assessment Criteria

The responses were scored for fluency (no. of ideas) and flexibility (no. of categories). Participant's creativity was then calculated by finding the average score from totalling the fluency and flexibility values. From the individual flexibility and fluency values the creativity quotient (CQ) was calculated. The mean values for fluency, flexibility and CQ were compared. However, to obtain the statistical significance of the difference between the three education systems the P-value was calculated. A p-value below 0.05 is generally considered statistically significant, while one of 0.05 or greater indicates no difference between the groups. The effect size of this difference was also analysed is using Cohen (1988) criteria of 0.1 = small effect, 0.3 = medium effect, and 0.5 = large effect (Pallant 2007) (Cohen, 2000).

Results

This paper reports the responses for the main question to assess student's creativity quotient, '*how many uses can you think of for a brick*'. Participant's flexibility was derived from the number of categories students noted in relation to uses of a brick. The number of ideas, fluency, in each category, was also calculated. From this the CQ was calculated. For example, the responses by Third level participant 9; are illustrated in Table 1; this student suggested 7 uses for a brick, which fall into 4 categories. This resulted in a CQ value of 5 (Figure 2, Appendix 1). Table 2 illustrates the fluency, flexibility and CQ values for the three levels of education, as total counts and average values.

Table 1: Sample response, uses for brick, participant 9

Categories:	Break something	Build something	Alternative positive uses	Alternative negative uses
Ideas	*Break a window*	*BBQ*	*Use it as a wedge*	*Use it as a weapon*
		Steps		
		House		
		Wall		

$$
\begin{aligned}
CQ &= \log_2 [(1+u_1)(1+u_2)(1+u_3)\ldots(1+u_c)] \\
&= \log_2 [(1+1)(1+4)(1+1)(1+1)] \\
&= \log_2 [40] \\
CQ &= 5
\end{aligned}
$$

Figure 2: Calculating the CQ for participant 9

Table 2: Fluency, flexibility and CQ values for three levels of education

		Count	Average
THIRD LEVEL	*Fluency (no of ideas)*	281	5.2
#54	*Product (1+u)*	3329	61.6
	Flexibility (no. of categories)	189	3.5
	CQ	230	4.3
SECONDARY LEVEL	*Fluency (no of ideas)*	312	4.3
#72	*Product (1+u)*	2470	34.3
	Flexibility (no. of categories)	238	3.3
	CQ	277	3.9
PRIMARY LEVEL	*Fluency (no of ideas)*	308	3.9
#78	*Product (1+u)*	1926	24.7
	Flexibility (no. of categories)	218	2.8
	CQ	266	3.4

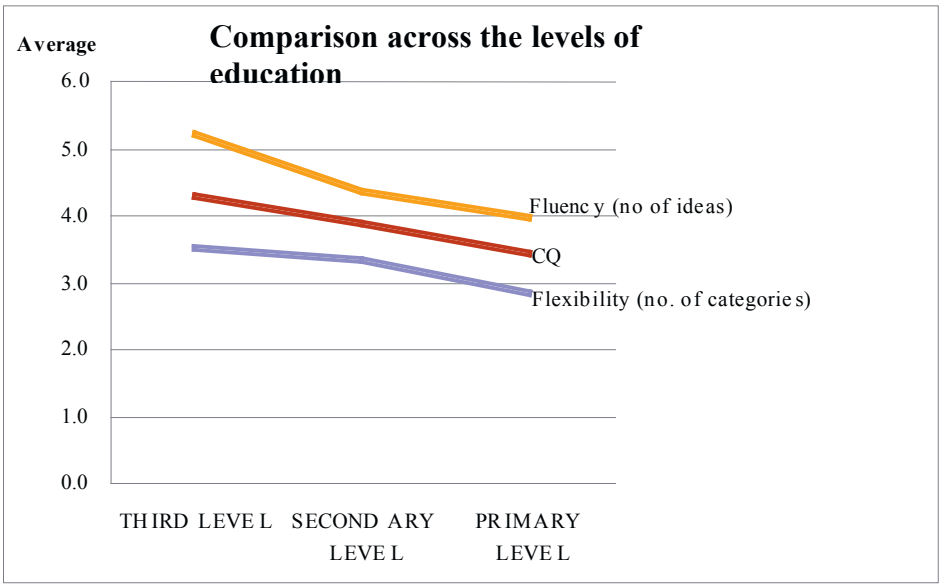

Figure 3: Comparison across the levels of education.

Due to the differing number of students in each level, the comparison of data occurred using mean values (Table 2). Students in third level demonstrated the highest average number of ideas, fluency, at 5.2, in contrast to 4.3 and 3.9 respectively for secondary and primary level. In relation to the number of categories, flexibility, the third level cohort achieved the greatest at 3.5, in contrast to 3.3 and 2.8 respectively for secondary and primary levels. Finally, in terms of CQ the third level cohort was 13% and 11% greater than the secondary and primary level cohorts respectively (Table 2, Figure 3).

Charting the statistical difference in progression

From the comparison across the levels of education in the context of fluency, flexibility and CQ it is evident that further statistical analysis needs to occur to determine the level of differences. A t-test was carried out on all three levels in the context of fluency, flexibility and CQ as evident in Table 3. Two education levels were analysed against each other. From the p-values illustrated, those below 0.05 are generally considered statistically significant, while those of 0.05 or greater indicate no difference between the levels, as illustrated in Table 4.

Table 3: Brick T test statistics (p-values)

Brick T-test			
FLUENCY	Primary level	Second level	Third level
Primary	-	0.0029	0.000447
Second	0.00288	-	0.334144
Third	0.00045	0.3341	-

Brick T-test			
FLEXIBILITY	Primary level	Second level	Third level
Primary	-	0.0386	0.043812
Second	0.03858	-	0.994557
Third	0.04381	0.9946	-

Brick T-test			
CQ	Primary level	Second level	Third level
Primary	-	0.0008	0.000071
Second	0.00081	-	0.255898
Third	0.000071	0.2559	-

Table 4: Statistical difference in fluency, flexibility and CQ across the education levels

	Level	Primary	Secondary	Third
Fluency	Primary	-	*Difference*	*Difference*
	Secondary	*Difference*	-	*No difference*
Flexibility	Primary	-	*Difference*	*Difference*
	Secondary	*Difference*	-	*No difference*
CQ	Primary	-	*Difference*	*Difference*
	Secondary	*Difference*	-	*No difference*

Discussion

The aim of this study was to investigate pupil's creativity capacity, through the creativity quotient, across the three levels of education in the Irish education system. Results have indicated that the mean CQ for third level students is 11% and 13% greater than secondary and primary levels, respectively.

However, on analysis of the p-value between the three levels of education it is evident there is a difference between first and second level; between second and third, there is no difference across fluency, flexibility and CQ. The progressive development from first level to second level could be due to the fact that first level does not have a compulsory technology education subject in the curriculum. Thus, second level increases students' level of creativity with respect to this subject. However, unfortunately this progressive development does not continue to third level for this cohort. A greater study involving a greater sample size is ongoing to investigate these findings further.

Thinking skills in an educational setting provide a social infrastructure to extend and develop organisations in the areas of creativity and innovation. Creating a pedagogical space for developing a model of creative learning which moves away from the 'teacher as a technician' model of educational pedagogy and 'learner as passive containers' towards learners as thinkers (Kansanen, 1991, pg 251) must be promoted. If society, as a body of thinkers, is nurtured and developed, their insights will be acknowledged and valued. In promoting students creative capacities pupils should be encouraged to solve "*practical problems in an innovative and creative manner through the application of appropriate knowledge and skills*" (Department of Education 1991, p.1).

Conclusion

As Pablo Picasso once pointed out, all children are creative; the challenge is to remain creative into adulthood. Unfortunately education systems around the world appear to be crushing creativity in favour of rote learning and examination success. As the years progress from primary to second level education a fear of being wrong takes over from our natural creative tendencies.

This study focused on investigating the level of creativity quotient between the levels of education in Ireland. The overall finding of the study presents two stances; the development from primary to

second level in terms of creative capacity is evident, thus pupils are not being educated out of their creative capacities. However, between second and third level, there is no statistical difference, thus students do not progressively develop their creative capacity. At present further studies are on-going across a greater cross section of participants in all three levels and across the STEM disciplines.

Appendix 1

Calculating fluency, flexibility and creativity quotient (CQ)

Flexibility – Category	Fluency - Ideas	u
HOLD SOMETHING	*No response*	
	(u+1)	0
HOLDER	*No response*	
	(u+1)	0
BREAK SOMETHING		
	Break a windscreen	1
	(u+1)	2
BUILD SOMETHING		
	Build a brick bbq	1
	Build a house	1
	Build a stairs / steps	1
	Build a wall	1
	(u+1)	5
KILL	*No response*	
	(u+1)	0
INJURE	*No response*	
	(u+1)	0
MAKE SOMETHING	*No response*	
	(u+1)	0
USES ASSOCIATED WITH A CAR	*No response*	
	(u+1)	0
ALTERNATIVE USES-positive		
	Use it as a wedge	1
	(u+1)	2
USES ASSOCIATED TO BUILDING	*No response*	
	(u+1)	0
ALTERNATIVE USES-negative		
	Use it as a weapon	1
	(u+1)	2
CHANGE IT BY…	No response	
	(u+1)	0
NOT ASSOCIATED TO 'USE'	*No response*	
	(u+1)	0
SPORT ASSOCIATIONS	*No response*	
	(u+1)	0
	Product (1+u)	40
	Fluency (no of ideas)	7
	Flexibility (no. of categories) (u)	4
	Creativity Quotient (CQ)	5

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