Evaluating *The Imagineerium*: The Trowsdale Indices of Confidence in Competence, Creativity and Learning (TICCCL)

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Abstract

In order to evaluate the impact of *The Imagineerium*, an arts and engineering based curriculum project, a pilot sample of 135 year 5 (9- to 10-year-old) students completed a battery of tests both before and after participating in the 10-week programme. The battery of tests included three measures proposed by the Trowsdale Indices of Confidence in Competence, Creativity and Learning (TICCCL), together with the three indices proposed by the Junior Eysenck Personality Questionnaire Revised (abbreviated form), namely extraversion, neuroticism and psychoticism. In accordance with the hypothesised effect of the programme on student learning, the data demonstrated a significant increase in all three measures of confidence in competence, creativity and learning, but no change in the three control variables (extraversion, neuroticism, and psychoticism).

Keywords: Imagineerium project, quantitative evaluation, competence, creativity, learning, creativity in education, creative learning, primary school

Highlights:

- Quantitative scales were tested for assessing confidence in competence, creativity and learning
- Each scale has good internal consistency reliability .
- Each scale recorded a significant increase following an educational intervention designed to improve these areas.
- There was no change in the control variables.
- The data support the effectiveness of *The Imagineerium* project.

Introduction

The Imagineerium

This paper reports on the development of a new measurement of students' confidence in competence, creativity and learning, developed through research into *The Imagineerium.* a distinctive arts and engineering project. During the project, 9- to10-year-old students work with professional 'imagineers' (artists, performers, designers and engineers) and their teachers, to imagine, to design, and to create partially working models of a mechanical, moving machine inspired by a story from local history. The designs are presented by the young Imagineers, who explain, demonstrate and enact physically their design ideas, to a local panel of heritage, arts and engineering experts. These experts select the best, which will be made to full scale and installed in a heritage park in the local city.

Through an imaginative 'mantle of the expert-like' frame (see Heathcote and Bolton 1995), adult imagineers induct the children into thinking and behaving 'like an imagineer' through art-making activities. They explore the ideas and human significance of their historical story through drama to identify, collaboratively, what they think might be the most resonant ideas for visitors to the heritage park. In addition to this use of drama, physical theatre is used to enable children to experience and understand principles of physical sciences in relation to forces and mechanisms (through construction and movement) using their bodies. They work practically, in groups, to understand how to create motion, exploring challenges in making, and using a range of materials. Idea generation, thinking and understanding is supported by the use of personal sketchbook/journals, by questioning and by talking.

The Imagineerium is designed to stimulate children's aspirations, to channel their inventiveness, and to feed their appetite for the engineering sciences and arts as related to creative practices and professions. It has been recognised as a particular kind of STEAM

education (Colucci-Gray, et al 2017) and reported on elsewhere as a particular, arts-rich, educational experience (Trowsdale, 2016) and 'practice-based' curriculum (Davies & Trowsdale, 2017).

The research

The notion of students' sense of confidence in their competence is widely understood in educational psychology. Bandura's notion of self-efficacy (Bandura, 1997) describes how the experience of achievement, and of being regarded as achieving, generates a sense of competence which both feeds, and is fed by, a person's broader sense of confidence and self-esteem as a learner. Behaving creatively, and the associated sense of autonomy and expressivity it facilitates, suggests a positive correlation with competence and learning. Varied conceptualisations of creativity have been advanced, even within the field of education (see Cropley, 2001; Lucas, Claxton, & Spencer, 2013; Runco, 2011; Sefton-Green, Thomson, & Jones, 2012; Lubart, 2017; Glaveanu, 2018). Increasingly these conceptual distinctions recognise the significance of context and purpose in characterising different possible 'kinds' or at least dimensions of creative behaviour. This study employs a pragmatic, best-fit account for this project. It has drawn upon Lucas, Claxton, and Spencer (2013), with attention to Lubart (2017) and Glaveneau (2013), to codify ideas which both formatively shaped the design and practice of *The Imagineerium,* and emerged inductively from analysis of early data. Thus the conception of 'creativity' in this educational study is as behaving imaginatively, inquisitively and collaboratively, and to a lesser degree persevering and being disciplined (Lucas, Claxton, & Spencer, 2013).

Learning from the qualitative studies

As suggested above, *The Imagineerium* design drew on the shared beliefs and practices of arts, engineering and education stakeholders involved in its development. This focused attention upon the design of a learning experience, which strongly echoed the real-

world freedoms, responsibilities and practices of artists and designers. Qualitative research into the project (Trowsdale, 2014, 2016) drew on a small sample of students. These earlier qualitative methods (questionnaires, interviews, journal entries - with students and also teachers) suggested a number of positive effects on learning. These included specific improvements, such as students' increased confidence in their understanding of National Curriculum Science curriculum, but also a more global positive effect in terms of students' self-view of their competence and creativity as learners. Questionnaires and students' reflections in post-project interviews had indicated an enhanced sense of confidence in their capability and appetite for learning. These appeared to be strongly associated with the conditions and practices inherent in the project pedagogy, particularly its 'creative' aspects.

Data collection over three years suggested the significance of imagining, making personal connections, collaborating, and enhancing students' motivation to learn, achieve and aspire. Students spoke about learning the value of work with different others, because you 'get to learn about each other', 'develop your listening', 'get used to working with people' and 'make better ideas'. They revealed a greater sense of pride 'I'm more proud of what I am doing'. They suggested that the effect of such practice could enable any student experiencing the project to 'learn what s/he is good at', that s/he is 'smarter than he thinks', 'more clever', 'intelligent', that s/he 'can now succeed', and would make 'more progress in learning'. The effect of such improved self-belief appeared to extend beyond the project itself, with students talking of maths, football and social situations in which 'sometimes I wouldn't really, like, believe in myself, but like now I believe in myself more'. This appeared to generate a sense of resilience so that 'If someone says "oh you're terrible"… show them what you actually are made of', or 'I think that now I know more about myself …. I can challenge myself to do more things'.

Against this background, there was a recognised need to test the impact of the programme on the population of students as a whole. Consequently we developed a questionnaire to evaluate the extent to which these apparent benefits were shared by all students. The questionnaire sought to test students' perceptions of their confidence in themselves as learners, especially as 'competent learners' (particularly as competent in their understanding of science and design and technology) and as 'creative learners' (particularly as imaginative inquisitive, resilient and collaborative learners).

Evaluating the existing instrument

The qualitative research suggested that the imaginative, inquisitive, collaborative and persistent behaviours encouraged by *The Imagineerium* were critical to the engagement of students' individual interests, fostered a sense of competence in learning, and developed students' autonomy as learners. The qualitative data reflected principles of self-efficacy (Bandura, 1997) and self-determination theories (see Ryan & Deci, 2000) identified in both as the basis of intrinsic motivation. However, while a wealth of research exists to test general self-efficacy and self-determination, including some in educational contexts, there appeared to be a paucity of applied research methods to investigate the development of 'creativity' in relation to 'self-efficacy' or 'self-determination'. Burnett (1994, 1999) had tested a series of sub-scales which explored aspects of learning and self-esteem, sometimes described as 'self-efficacy', with upper primary-age students. While the scope of their questionnaire focused more on the whole student, here was an instrument worth drawing on. On this basis we began with Burnett's self-scoring instrument, as a model for our bespoke development. The Burnett (1999) questionnaire comprises 44 questions, ten sub-scales of 4 questions, with one of 8 questions. For each of the questions, students choose one of five statements, reflecting a scaled response to an idea, for example, 'I really like learning new things', 'I like learning

new things', 'I sometimes like learning new things', 'I don't like learning new things' or 'I really don't like learning new things'.

We also took into account Bandura's advice that 'there is no all-purpose measure of perceived self-efficacy … most of the items in an all-purpose test may have little or no relevance to the domain of functioning [because they are] usually cast in general terms divorced from the situational demands and circumstances' (Bandura, 2006, p. 307). He argued that the ambiguity of such results, rendered them of questionable value and that self-efficacy needed to be tested in relation to a precise contextualised concept: thus tests should be bespoke. While Burnett's questionnaire operated with a series of statements for each question, Bandura recommended single statements with a likert-like scale tests (Bandura 2006). Early testing of layout, language and visuals with teachers and students suggested that a visual scale of icons would work better with this age group of students, rather than a word scale, or Burnett's word heavy scale. Consequently, we used five familiar emojis which reflect a spectrum of feelings in relation to the given statement. We drew upon the statements at the heart of a number of Burnett's scales: global self-esteem, school work, learning and mathematics. We also developed new statements iteratively to capture the subject areas of science, design and technology, art and the creative learning behaviours which underpin *The Imagineerium.* These, we expected, would enable students to recognise the statements as situated in typical learning situations, or in recent experience of *The Imagineerium*. Clarity of phrasing was tested with all teachers involved in the project and with a sample of 24 students across three schools. Statements were developed iteratively to reflect more precisely the creative and learning practices and possibilities that *The Imagineerium* might facilitate.

Initially this instrument was employed in an experimental design, pilot study conducted with intervention (attended *The Imagineerium*) and control (received regular science and arts education) groups. However, as widely recognised real world interventions,

such as this project, do not lend themselves either to randomization or control measures. Despite verbal agreement prior to the study, schools supplemented the educational experience of control group classes, in similar ways to the intervention, resulting in no significant difference in the results between the two groups. Clearly control groups do not work well for this kind of real world intervention.

Research questions

Against this background the aims of the present study are: to explore and examine the development of measures relevant for assessing confidence in competence, creativity and learning; to design a pilot study to assess the impact of appropriate educational interventions employing *The Imagineerium* on confidence in competence, creativity, and learning; and to identify appropriate control variables that could be integrated into the project, in place of trying to recruit and sustain control groups.

Control variables

Control variables were included in the project in order to test the consistency of the participants' responses to constructs without immediate relevance to the curriculum programme. The hypothesis is that, while the programme may have exercised some effect on the levels of confidence in competence, creativity and learning, it should have exercised no effect on the control variables. Control variables were employed rather than a control group in light of the practical difficulties outlined above. The control variables selected for this pilot testing were the three scales (extraversion, neuroticism and psychoticism) proposed by the abbreviated form of the Junior Eysenck Personality Questionnaire developed by Francis (1996), a 24-item adaption of the longer instrument proposed by Corulla (1990).

Method

Procedure

The questionnaire was administered, by teachers, to the participants twice, once at the beginning of the programme and again at the end of the programme. Teachers were both trained in and followed an agreed script to ensure that the same wording was used in all schools. Participants were assured of confidentiality with questionnaires completed anonymously. The programme and the assessment were conducted in accordance with the ethical procedures of the university and with parental consent.

Participants

A total of 135 students provided full data at both time one and time two. At time one 50% of students were 9 years old and 50% were 10 years old. By time two 21% of students were 9 years old and 79% were 10 years old. Of the 135 students 52% were male and 48% were female.

Instrument

The *Me and My Learning* questionnaire comprised four sections. *Section A* collected basic demographic data on sex, age and family background. *Section B* comprised 62 questions concerning a whole range of attitudinal questions conceiving the experience of learning, including specific questions related to confidence in learning and to confidence in creativity. Each item was rated on a five-point scale: agree strongly (5), agree (4), not certain (3), disagree (2), and strongly disagree (1). *Section C* comprised 11 questions concerning perception of competence. Each item was rated on a five-point scale: agree strongly (5), agree (4), not certain (3), disagree (2), and strongly disagree (1). *Section D* comprised the abbreviated form of the Junior Eysenck Personality Questionnaire Revised (Francis, 1996). This instrument includes three six-item scales of extraversion, neuroticism, and psychoticism. Each item is rated on a two-point scale: yes (1), and no (0).

Analysis

The data were analysed by the SPSS package utilising the frequencies, correlations, factor, reliability, and paired t-test routines.

Results and discussion

- insert table 1 about here -

The first step in the data analysis explored the factor structure of the 62 items in Section B of the questionnaire to test the hypothesis that confidence in learning and confidence in creativity comprised discernible and discrete factors. Using principle components analysis and varimax rotation, table 1 presents the clearest factor solution. In this two factor solution all loadings of .4 and below have been suppressed, leaving clearly the differentiation between the 11 items loading on factor one (confidence in learning) and the 14 items loading on factor two (confidence in creativity)

- insert table 2 and 3 about here -

Table 2 explores the scaling properties of the proposed 11-item Scale of Confidence in Learning. The alpha coefficient ($\alpha = .89$) demonstrates good internal consistency reliability. The correlations between the individual items and the sum of the other 10 items (ranging from .43 to .77) demonstrate that each item is playing a coherent part in the homogeneous scale. The item endorsements (ranging from 22% to 77%) demonstrate a good spread of item discrimination.

Table 3 explores the scaling properties of the proposed 14-item Scale of Confidence in Creativity. The alpha coefficients ($\alpha = .86$) demonstrates good internal consistency reliability. The correlations between the individual items and the sum of the other 13 items (ranging from .37 to .66) demonstrate that each item is playing a coherent part in the homogeneous scale. The item endorsements (ranging from 35% to 69%) demonstrate an acceptable spread of item discrimination.

- insert table 4 about here -

The second step in data analysis explored the scaling properties of the 11 items in Section C of the questionnaire to test the hypothesis that confidence in competence comprised a third identifiable construct. Table 4 explores the scaling properties of the 9 items identified as generating the clearest and strongest factor. The alpha coefficient ($\alpha = .75$) demonstrates acceptable internal consistency reliability. The correlations between the individual items and the sum of the other 8 items (ranging from .36 to .53) demonstrate that each item is playing a coherent part in the homogeneous scale. The item endorsement (ranging from 18% to 74%) demonstrate a good spread of item discrimination.

- insert table 5 about here -

The third step in data analysis explored the potential differences in scores at time one and at time two recorded on the three scales of confidence in learning, confidence in creativity, and confidence in competence, together with the three control variables (extraversion, neuroticism, and psychoticism). The data presented in Table 5 demonstrated a significant increase between time one and time two on the three measures of confidence in learning, confidence in creativity, and confidence in competence, but no significant difference between time one and time two on the three control variables. These findings support the effectiveness of the intervention educational programme of *The Imagineerium*.

Conclusion

Against the background of introducing the theory and practice of *The Imagineerium*, this study set out to address three research questions. The first research question concerned exploring and examining the design and development of measures relevant for assessing confidence in competence, creativity and learning. Drawing on data provided by 135 9- to 10-year-old students, three measures have been developed and tested: an 11-item Scale of Confidence in Learning (alpha = .89), a 14-item Scale of Confidence in Creativity (alpha = .86), and a 9-item Scale of Confidence in Competence (alpha = .75). Together these three

measures comprise the Trowsdale Indices of Confidence in Competence, Creativity and Learning (TICCCL). The psychometric properties of these instruments commend them for further use.

The second research question concerned designing a pilot study to assess the impact of appropriate educational intervention employing *The Imagineerium* on confidence in competence, creativity and learning. Data provided by these 135 9- to 10-year-old students both before and after the educational intervention demonstrated a significant increase in all three measures of confidence in competence, creativity and learning, over the course of the intervention experience. This finding supports the value of the educational intervention, in the sense that this intervention achieved an educational impact across the areas on which it was hypothesised to have effect. This finding also supports the construct validity of the three measures proposed by the Trowsdale Indices of Confidence in Competence, Creativity and Learning, in the sense that all three measures recorded impact from the educational intervention that were hypothesised to enhance confidence in these three areas.

The third research question concerned identifying appropriate control variables that could be integrated into the project to compensate for the impracticability of a control group to be set alongside the experimental group within the constraints of this pilot study. In the absence of a control group the theory is that the effectiveness of the intervention would impact the variables specific to that intervention (namely confidence in competence, creativity and learning) but at the same time would not impact the control variables. The three control variables incorporated in the present study were the extraversion, neuroticism and psychoticism scales proposed by the abbreviated form of the Junior Eysenck Personality Questionnaire developed by Francis (1996). Data provided by the 135 9- to 10-year-old students, before and after the educational intervention demonstrated no significant difference between the scores recorded on these three scales on the two occasions. This finding suggests

that the educational intervention had no effect on these three variables, confirming stability among the participants on these variables in contrast with the shifts taking place in the three variables hypothesised to be influenced by the educational intervention.

There are clear limitations with a pilot study of this nature that can be addressed in future research. Future research would be advised to involve a larger number of students within the experimental environment and to employ a carefully constructed control group of students not exposed to the educational intervention. What the pilot study has achieved is the demonstration that both the educational intervention and the newly designed Trowsdale Indices of Confidence in Competence, Creativity and learning are worth further investment.

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References

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (Vol. 5, pp. 307-337). Greenwich, CT: Information Age Publishing.

Burnett, P. C. (1994). Self-concept and self-esteem in elementary school children. *Psychology in the Schools, 31* (2), 164-171.

Burnett P. (1999). Burnett self-scale (BSS). Available online: http://eprints.qut.edu.au/

Colucci-Gray, L., Burnard, P., Cooke, C., Davies, R., Gray, D. and Trowsdale, J. (2017). *BERA Research Commission Report. Reviewing the Potential and Challenges of Developing STEAM Education through Creative Pedagogies for 21st Century Learning: How can school curricula be broadened towards a more responsive, dynamic and inclusive form of education?* London: British Educational Research Association.

Corulla, W. J. (1990). A revised version of the psychoticism scale for children. *Personality and Individual Differences, 11*, 65-76. doi.org/10.1016/0191-8869(90)90169-R

Cropley, A. (2001). *Creativity in education and learning: A guide for teachers and Educators.* London: Routledge

Davies, R. and Trowsdale, J. (2017). The value of instability: Lessons from reviewing how and why creativity and the arts might interact with STEM education. *European Journal of Curriculum Studies, 4* (1), 584-600.

Francis, L. J. (1996). The development of an abbreviated form of the Revised Junior Eysenck Personality Questionnaire (JEPQR-A) among 13- to 15-year-olds. *Personality and Individual Differences, 21*, 835-844. doi.org/10.1016/S0191-8869(96)00159-6

Glăveanu, V. P. (2013). Rewriting the language of creativity: The Five A's framework.

Review of General Psychology, *17* (1), 69-81.

Glăveanu, V. P. (2018). Educating which creativity? *Thinking Skills and Creativity*, *27*, 25-32.

Heathcote, D., and Bolton, G. (1995). *Drama for Learning: Dorothy Heathcote's Mantle of the Expert Approach to Education (Dimensions of Drama).* Portsmouth, NH: Heinemann

Lucas, B., G. Claxton and E. Spencer (2013). Progression in student creativity in school: First steps towards new forms of formative assessments. *OECD Education Working Papers*, No. 86, OECD Publishing. doi.org/10.1787/5k4dp59msdwk-en

Lubart, T. (2017). The 7 Cs of creativity. *The Journal of Creative Behaviour*, *51* (4), 293-296.

Runco, M. (2011). *Encyclopaedia of Creativity*, San Diego, CA: Elsevier Science Publishing

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being, *American Psychologist, 55*, 68–78.

Sefton-Green, J., Thomson, P. and Jones, K. (2012). *The Routledge international handbook of creative learning*, London: Routledge

Trowsdale, J. (2014). *The Imagineerium – pilot project (with schools) report*. Coventry: University of Warwick.

Trowsdale, J. (2016) Imagineering: Re-creating spaces through art-making. *Creativity: Theories, research, applications*, 3 (2), 274–291. doi.org/10.1515/ctra-2016-0018

Table 1 *Factor analysis, rotated solution*

	factor	
	One	two
I am good at learning	.71	
I enjoy learning	.68	
I find learning easy	.42	
I feel good about myself and how well I learn	.65	
I feel proud about myself as a learner	.81	
I usually feel I am able to do the work I am asked to do	.65	
I feel confident that I can do well at school	.68	
I feel happy with how well I am learning	.81	
I like to find things out	.48	
I work hard at developing new skills and techniques	.58	
I am usually interested in learning	.69	
I am good at working out what I need to do to improve something		.53
I am usually up for ‘having a go’ at new things		.55
I am an imaginative person		.45
I am good at coming up with lots of good and new ideas		.48
I am good at spotting similarities and differences between things		.48
I am good at putting things together to make something new		.76
I am good at seeing how something could be done differently		.62
I can often see how to improve an idea		.65
I am good at experimenting with different ways of doing things		.59
I offer good suggestions in group discussions		.50
I am good at experimenting with things just to see what happens		.64
If something doesn’t work I will look into what has gone wrong		.53
I give good reasons for my ideas and answers		.51
I am good at deciding what needs to be said when explaining an idea		.52

Table 2

Scale of Confidence in Learning reliabilities

	r	%
I am good at learning	.71	49
I enjoy learning	.56	74
I find learning easy	.43	22
I feel good about myself and how well I learn	.64	64
I feel proud about myself as a learner	.68	62
I usually feel I am able to do the work I am asked to do	.62	62
I feel confident that I can do well at school	.69	67
I feel happy with how well I am learning	.77	71
I like to find things out	.48	77
I work hard at developing new skills and techniques	.60	56
I am usually interested in learning	.62	60
Alpha coefficient	.89	

Note % = sum of agree and agree strongly responses

r = correlation between individual item and sum of other ten items

Table 3

Scale of Confidence in Creativity reliabilities

	r	%
I am good at working out what I need to do to improve something	.55	48
I am usually up for 'having a go' at new things	.55	69
I am an imaginative person	.37	68
I am good at coming up with lots of good and new ideas	.44	46
I am good at spotting similarities and differences between things	.43	45
I am good at putting things together to make something new	.56	56
I am good at seeing how something could be done differently	.54	46
I can often see how to improve an idea	.66	45
I am good at experimenting with different ways of doing things	.55	51
I offer good suggestions in group discussions	.50	51
I am good at experimenting with things just to see what happens	.52	60
If something doesn't work I will look into what has gone wrong	.52	64
I give good reasons for my ideas and answers	.55	37
I am good at deciding what needs to be said when explaining an idea	.49	35
Alpha coefficient	.86	

Note % = sum of agree and agree strongly responses

r = correlation between individual item and sum of other ten items

Table 4

Scale of Confidence in Competence reliabilities

	r	%
I can explain how forces work in machines	.53	18
I can explain how mechanisms work (e.g. lever, cam, pulley, cogs and gears)	.49	23
I can explain how 'resistance' effects how something moves	.40	30
I can explain the physical properties of different materials (e.g hard, soft)	.38	55
I can compare different materials to see which is best for a particular purpose	.38	47
I know how to make a drawing or model of something to scale	.36	44
I can label my sketches to explain things I design	.41	74
I can make prototypes for (bits of) my design ideas	.42	40
I can explain what materials would be suitable for my design ideas	.47	60
Alpha coefficient	.75	

Note % = sum of agree and agree strongly responses

r = correlation between individual item and sum of other ten items

Table 5

Change over time

	Time one		*Time two*		*t*	p<
	Mean	SD	Mean	SD		
Experimental variables						
Confidence in learning	41.00	7.21	42.05	6.41	2.07	.05
Confidence in creativity	49.70	7.92	51.21	7.20	3.03	.01
Confidence in competence	29.14	5.32	33.15	1.15	8.53	.001
Control variables						
Extraversion	4.36	1.50	4.46	1.35	0.72	NS
Neuroticism	3.16	1.64	3.22	1.71	0.42	NS
Psychoticism	0.71	1.05	0.81	1.09	1.35	NS