Education Research International

Education for Creativity and Talent Development in the 21st Century

Lead Guest Editor: Kirsi Tirri
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Editorial Board

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Hindawi
Education Research International
Volume 2017, Article ID 5417087, 2 pages
https://doi.org/10.1155/2017/5417087

Editorial

Education for Creativity and Talent Development in the 21st Century

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Received 26 October 2017; Accepted 26 October 2017; Published 16 November 2017

The world is facing challenges in the 21st century that are very different from those in the previous centuries. Globalization, new technology, and knowledge growth in today's societies call for creative and purposeful citizens who can combine excellence with ethics. Gifted students and professionals in science create new ideas and products that can be used in the benefit of our society. However, the creative process in science includes many ethical issues that need to be considered before publishing the new idea or the product. A globalized tendency has been to reform education to nurture the 21st century competences of our youth.

The 21st century competences can be defined as an integration of knowledge, skills, attitudes, and values, which young people are required to have in the 21st century. Many international organizations, such as the United Nations Educational, Scientific and Cultural Organization, the Organization for Economic Cooperation and Development, and the European Union have published documents outlining educational goals for the 21st century emphasizing creativity as an important goal.

Meanwhile, international companies, for example, Intel Corporation and Microsoft Corporation, have collaborated with educators and educational institutions for developing frameworks for teaching and assessing the 21st century competences. The discussion of the 21st century competences has been an important topic in creativity and talent development research as well. In this discussion, creativity has been as one of the most important competences we should nurture in our youth.

The focus of this special issue is on the education for creativity and talent development in different fields including arts and humanities. This special issue is an international forum for researchers to summarize the most recent developments and ideas in the field, with a special emphasis given to the challenges of the 21st century creativity.

In the article "Creativity as a Stepping Stone towards Developing Other Competencies in Classrooms" by N. Ahmadi and M. Besançon from France, the main objective is to review the literature on creativity considering the other 21st century skills as well. The main hypothesis of the article is that the introduction of creative practices in classroom can possibly lead to developing other competencies of pupils at the same time. The review of the literature is based mostly on the theatrical link between creativity and critical thinking, between creativity and metacognition, and, last, between creativity and collaboration skills. Finally, the authors discuss these findings considering teachers' training and the nature of classroom activities.

In the empirical study of 607 Finnish students "How Do School Children and Adolescents Perceive the Nature of Talent Development? A Case Study from Finland" by E. Kuusisto et al., the authors report results on the relation between implicit beliefs on intelligence and giftedness and students' academic achievements. The findings reveal that growth-oriented views about intelligence, but fixed ideas about giftedness, indicated higher math grades. The results suggest that the relationship between implicit beliefs and academic outcomes might not be as straightforward as previous studies have suggested.

Two of the articles investigate creativity and mathematical ability. The study from Taiwan "Threshold Effects of Creative

Problem-Solving Attributes on Creativity in the Math Abilities of Taiwanese Upper Elementary Students" by C.-Y. Lin investigated the typology of the math creative problem-solving abilities of 409 fifth- and sixth-grade Taiwanese students. A Creative Problem-Solving Attribute Instrument was also devised with the aim of measuring students' perceptions on their motivation, knowledge, and skills, both in general and in specific domains. The results suggest a threshold effect from several attributes—divergent thinking, convergent thinking, motivation, general knowledge and skills, domain-specific knowledge and skills, and environment—on students' creative problem-solving abilities.

The article from Finland "Hands-On Math and Art Exhibition Promoting Science Attitudes and Educational Plans" by H. Thuneberg et al., investigated the differences in experiences of learning mathematics between the contexts of school and an informal Math and Art Exhibition. The study participants ($N = 256$) were 12-13-year-olds from Finland. The lowest achieving group appreciated the exhibition alternative for math learning compared to learning math at school. The boys considered the exhibition to be more useful than the girls as it fostered their science and technology attitudes. However, for the girls, the attractiveness of the exhibition, the experienced situation motivation, was much more strongly connected to the attitudes on science and technology and the worthiness of mathematics. Interestingly, the pupils experienced that even this short informal learning intervention affected their science and technology attitudes and educational plans.

The case study from the Netherlands "Preparing Students for Global Citizenship: The Effects of a Dutch Undergraduate Honors Course" by I. W. Schutte et al., investigates effects on the participating students ($N = 25$) of an undergraduate honors course, aimed at global justice citizenship. The Ethical Sensitivity Scale Questionnaire and the Global Citizenship Scale were used in a pre- and posttest design to measure possible development in the moral and civic domain among the participants of the course. Quantitative results show increased ethical sensitivity as well as global civic engagement and global competence among the participants. Qualitative results point in the same direction and provide deeper insights in the content of students' learning and the perceived impact of the course on their attitudes and behavior. Results are discussed in relation to theory on justice-oriented global citizenship and honors pedagogies.

Taken together, all the articles in this special issue address the importance of education for creativity and talent development in different fields, contexts, and countries. The editors of this issue are delighted to see the diverse conceptual and methodological approaches in these studies and encourage the researchers to further widen their approaches in the growing field of creativity and talent development research.

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Hindawi
Education Research International
Volume 2017, Article ID 9132791, 13 pages
https://doi.org/10.1155/2017/9132791

Research Article

Hands-On Math and Art Exhibition Promoting Science Attitudes and Educational Plans

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Received 24 March 2017; Revised 24 July 2017; Accepted 10 September 2017; Published 18 October 2017

Academic Editor: Seokhee Cho

The current science, technology, engineering, art, math education (STEAM) approach emphasizes integration of abstract science and mathematical ideas for concrete solutions by art. The main aim was to find out how experience of learning mathematics differed between the contexts of school and an informal Math and Art Exhibition. The study participants ($N = 256$) were 12-13 years old from Finland. Several valid questionnaires and tests were applied (e.g., SRQ-A, RAVEN) in pre- and postdesign showing a good reliability. The results based on General Linear Modeling and Structural Equation Path Modeling underline the motivational effects. The experience of the effectiveness of hands-on learning at school and at the exhibition was not consistent across the subgroups. The lowest achieving group appreciated the exhibition alternative for math learning compared to learning math at school. The boys considered the exhibition to be more useful than the girls as it fostered their science and technology attitudes. However, for the girls, the attractiveness of the exhibition, the experienced situation motivation, was much more strongly connected to the attitudes on science and technology and the worthiness of mathematics. Interestingly, the pupils experienced that even this short informal learning intervention affected their science and technology attitudes and educational plans.

1. Introduction

Children start to learn mathematics long before they are exposed to formal teaching at school [1]. Nearly all children have some sense of numbers from early on, are capable of counting the basic numbers ("one, two, three, etc."), and are proud to tell their own age. They get to know the basic geometrical shapes and objects like circles, balls, and squares in natural everyday situations. Further, they can tell the time, use money by playing shop, compare and evaluate the magnitude of figures, and strategize, for example, by playing cards. Preschool aged kids get involved with applied mathematics also through ICT and digitalization while playing computer games or using tablet and smartphone applications. This learning of mathematics most often happens unconsciously. This is typically informal learning [2], which can also be utilized in a science exhibition context [3].

However, the older the children, the more complicated the mathematical problems they encounter in everyday situations, especially when they start school. Then, it becomes crucial to exploit their natural curiosity, imagination, and willingness to play [4] in the learning of mathematics and to support them to discover the meaningfulness and worth of mathematics. According to the TIMSS 2015 study (TIMMS: Trends in International Mathematics and Science Study), half of the international fourth-grade mathematics curricula include attitudes and mention, for example, beliefs, confidence, and perseverance as well as the beauty of mathematics, developing a productive disposition toward mathematics, appreciating the practical applications of mathematics in life, and displaying a constructively critical attitude toward mathematics [5]. Some countries mention appreciation of scientific inquiry and science as a discipline or curiosity and interest.

The current science, technology, engineering, art, mathematics education (STEAM) approach underlines integration of abstract mathematical ideas to find concrete solutions and evidence by art [6]. Children have to be able to use their senses and hands-on experimentation in order to test their thinking, especially at the concrete operational stage [7]. The importance of own exploration and experience is supported by the principle of learning by doing by Dewey [8] and the key of science center pedagogy, hands-on activity by Oppenheimer [9]. In case of math learning, manipulation of materials in multiple ways allows abstract mathematical concepts to become understandable, creative problem-solving to become possible, and mathematics to become meaningful [10]. Hands-on activities and exploration involve factors that enhance creativity: the encouragement of questions and novel initiatives and the offering of opportunities to discuss and debate problems with others [11]. Usually, these are perceived as welcoming challenges by high-achieving students. The empirical results of a study by Mann [12] that explored elements of mathematical creativity in middle school students showed that the strongest predictor was math achievement; it explained one-quarter of the variance. And one half of that predicted gender, attitudes toward mathematics, and belief in one's own creative abilities. However, mathematical giftedness does not always guarantee mathematical creativity [13]. Further, high achievement or giftedness can sometimes be connected with perfectionism, in which case a fear of failure might turn to avoidance orientation and lead to underachievement as Mofield et al. [14] stated.

Pupils have shown that, through using a hands-on method, they like learning more, learn and remember better [15], and attribute their learning outcomes more to hands-on than to traditional teaching methods, or only to seeing or to hearing things. Liking and motivation have been shown to be connected to developing mathematical metacognition, which along with reduced anxiety supports problem-solving [16]. As with the children, teachers have reported that the hands-on method has been the most effective method for their pupils [17]. These benefits of the hands-on method have been shown to apply to a diverse number of learners, from pupils with mild disabilities [18] to pupils with serious emotional disturbances [19].

In this article, mathematical problem-solving was combined with art. The learning context was a Math and Art Exhibition, and the mix of math learning and art was represented in the building of mathematical geometric models with concrete materials. These activities require visual imagery and mental rotation. According to Hope [20], the capacity and skill to create visual representations of the mental images form an essential part of the learning process. Although the immediate goal was to enhance math learning, these activities support the development of spatial skills [21] and spatial intelligence, which have been identified as important factors of school achievement in general [22].

According to Fenyvesi et al. [23], problem-solving can also be a basis for the integration of learning mathematics in transdisciplinary educational frameworks, such as STEAM integration, although the integration of liberal arts into STEM is mutually reshaping scientific education and humanities education [24]. It seems evident that, just like mathematics learning, it is recommended that science, technology, engineering, and arts education also follow problem-oriented approaches.

As the creative element and esthetic component are the inherent core of art, combining art with math learning offers an additional dimension for concretizing math concepts. Art and math have been considered to share many principles, for example, space and shape [25], but also that of esthetics, as Mack [26] discusses in his article "A Deweyan perspective on esthetic in mathematics education." The synthesis of math and art might show the beauty of both domains and possibly in a novel light. As such, by applying art, ways of looking and observing become critical [27].

Making art, *"Kunst,"* requires practical skills and handicraft. However, it is also an emotional process involving play, risk-taking, and imagination. The imagination has often been undermined in teaching academic school subjects, although it is crucial for "inventive scholarship" [28]. A combination of math and art invites pupils to approach math problems from a new perspective [29] because imagination, which is closely related to art, gives the possibility of "seeing things other than the way they are", as Eisner [28] states. When this artistic math learning process with its esthetic beauty is shared with others, it creates an emotional experience, which then is likely to support also cognitive learning and the retention of learned contents and skills [30] and the "convergence of both cognitive and emotional parts of the mind" [26]. Because mathematical problem-solving has been shown to involve affective factors [16], such as anxiety, these kinds of shared activities might ease negative experiences and feelings.

Although art in science has recently become more prominent in the move from STEM to STEAM [23], according to Hickman and Huckstep [29], the role of art, at least in math education, lacks research evidence. However, there are more recent results related to this topic [31–33].

Learning in informal contexts has often been regarded as the opposite of formal education and critical toward traditions as is depicted in Ivan Illich's [34] classical presentation *Deschooling Society*. One of the main difficulties is that pure informal learning refuses to be categorized, and the definitions are not needed until informal learning becomes institutionalized. In this sense, it has often been described as a creative way of learning as is the case in Gardner's [35] book, *The Unschooled Mind*, which he points out also with the element of reframing [36].

The main results related to informal creative exhibition learning underline the motivational effects. In particular, the role of situation motivation seems to be essential [37]. Also, novelty has turned out to be one of the key factors in creating interest and situation motivation in the open learning environment [33], which can be interest-based settings that motivate otherwise non-mathematically oriented pupils. The dilemma of the informal creative pedagogy is how to enhance this strong situation motivation to support its transformation into intrinsic motivation and deep-learning strategy. As such, it is also a challenge of this study and is embedded in the main research questions.

Research Questions. The research questions were as follows:

(1) How does the pupils' experience of learning mathematics differ in the school context and in the exhibition context?

(2) How does the experienced worth of mathematics and belief of hands-on effectiveness on learning change after the Math and Art Exhibition?

(3) What is the role of situation motivation and other variables on change of attitudes toward science and technology and on the future educational aspirations of pupils?

These questions are analyzed in regard to gender and math achievement groups. The role of cognitive, visual reasoning, autonomous motivation, and pretest variables was controlled in the constructed SEM model.

2. Materials and Methods

2.1. Participants. The participants in Math and Art Exhibition were 12 to 13 years old from a city in Middle Finland (N = 256), 52% girls (n = 134) and 48% boys (n = 122). The five randomly selected schools were chosen from the schools which had preregistered for the mobile exhibition. The study was conducted following the research's ethical principles.

2.2. Context of the Study: Learning Mathematics by Hands-On Activities. The context of this study was a mobile interactive mathematics exhibition Art of Math. The exhibition consisted of eleven interactive "hands-on" science exhibition objects, which the students were allowed to use, test, explore, and learn freely during a 45-minute time period. Following that, they attended a workshop (also 45 minutes) in which they were allowed to build their own structures and creatures by using and applying the small "Lego" type of plastic pipes and circles.

The 4Dframe construction system and building set was developed by Park Hogul, who is a Korean engineer and model maker originally inspired by classical Korean architecture [23] with inspirations of other mathematical and artistic approaches [33]. His concept is based upon the structural analysis and geometric formalization of building techniques utilized in the construction of Korea's traditional, wooden buildings. The set itself consists of 2–30 cm long "tubes" and various types of "connectors": just a small number of elegantly structured, simple module pieces made out of polypropylene, which are flexible enough for the construction of "unbreakable" modules and spatial formations as well [23]. The wealth of structural variability offered by this versatile device renders it an excellent tool for conceptualizing, modeling, or analyzing structures and topics relevant to geometry, engineering, architecture, design, or art. Due to its numerous advantages and flexibility, the 4Dframe is adaptable to a wide variety of complex educational uses [23].

The central aim underlying 4Dframe educational methodology [38] is to activate students' familiarity with geometric structures within the context of problem-solving. This method is based upon the creative exploration of these structures and uses a step-by-step approach to scientifically analyze each stage in the construction process. The 4Dframe also provides opportunities to experiment with creative methods related to mathematical art.

2.3. Measures

2.3.1. Deci-Ryan Autonomous Motivation. The Deci-Ryan scale measuring autonomous motivation was based on self-determination theory (SDT). It was administrated as a pretest, and the variable was used as a covariate in the structural equation model in order to reveal the purified influence of the short-time situation motivation in the exhibition context.

The Deci-Ryan Motivation (SRQ-A: Self-Regulation Quality-Academic) scale has 32 standardized items with four Likert options: 1 = not at all true, 2 = not nearly true, 3 = somewhat true, and 4 = totally true (for the translation into Finnish, see Thuneberg, 2007). The questions correspond with the self-regulation styles on the self-determination continuum. For example, the students are asked about the reasons why they do their homework or try to answer hard questions during lessons. The summative variables forming the self-determination continuum from the external toward the intrinsic direction are as follows: external, introjected, identified, and intrinsic. Based on the formula by Ryan and Connell presented in the validation article of the SRQ-A [39], the RAI (Relative Autonomy Index) of the summative variables (i.e., external, introjected, identified, intrinsic) was calculated. The RAI describes the overall relative autonomy level of the pupil. The positive plus sign in RAI indicates that the experience is rather autonomous, and the negative minus sign indicates that one relies more on others than trusting in one-self.

The reliability of the SRQ-A was checked. It was good, Cronbach's α = .895, 32 items.

2.3.2. Situation Motivation Test. The situation motivation questionnaire consisted of 12 Likert scale items (scale: 1–5, from "totally agree" to "totally disagree"). The questionnaire was constructed by the authors, piloted in a small group of 12-year-olds, and used before this present study in other studies. The questionnaire was administered as a posttest. The items were constructed and instrumentalized in relation to extrinsic elements like "edutainment" and recommendable outer aspects. The questions explored how attractive the pupils viewed the exhibition, for example, as follows: I was able to experiment and do many things by myself; I wish I would have had a chance to stay longer at the exhibition; I would recommend the math exhibition to others. The reliability of the measure was good, Cronbach's α = .895, 12 items.

2.3.3. RAVEN Test. The cognitive measure was the visual reasoning test RAVEN Standard Progressive Matrices [40]. The test measures visual nonverbal cognitive skills [41]. It has been shown to be a reliable standardized tool for comparing an individual's learning abilities with the age group, irrespective of sex.

In each test item, the subject is asked to identify the missing element that completes a pattern. The test contains 60 items divided into five sets (A, B, C, D, and E), each including

12 different tasks. The reliability was good, Cronbach's α = .845, 60 items.

2.3.4. Math Achievement. Math grade was used as a math achievement indicator. The scale of the school subject grades in Finland goes from 4 to 10. In addition to using the math grade as a continuous variable, pupils were categorized in math achievement quartiles, and that grouping was applied in the analyses.

Liking Math at School Context and Liking Math at Exhibition Context. The single variables, which were summed, were formulated by the authors and were the same in the pre- and posttest. The only exception was that in the first one the items were related to school and in the second to exhibition. Following are examples of the 14 semantic differential items: *I think that math learning at the school/at the exhibition was important/useless (scale 1–5, with 5 indicating "important" and 1 indicating "useless"), modern/old-fashioned (scale 1–5, with 5 indicating "modern" and 1 indicating "old-fashioned"), and clear/confusing (scale 1–5, with 5 indicating "clear" and 1 indicating "confusing")*: pretest Cronbach's α = .90, 14 items; posttest Cronbach's α = .90, 14 items (note: in pretest, time point 1 has been abbreviated to T1; in posttest, time point 2 has been abbreviated to T2).

2.3.5. Experienced Worth of Maths. The summed variable was formed out of six single variables formulated by the authors. The question was, *What do you think of the statement*? The scale ranged from 1 (not agree at all) to 5 (totally agree). The statements were as follows: *Math makes my everyday life easier. Understanding mathematics supports me in many practical situations. It is important to understand mathematical phenomena. Mathematics is interesting. Mathematics is useful in many occupations*: pretest Cronbach's α = .86, 5 items; posttest Cronbach's α = .82, 5 items.

The next three measures were single items. It is rather unconventional to apply single-item variables, but single items have been shown to yield reliable and valid data and predict outcomes effectively in certain conditions [42–45]. They even might be more economical and suitable than multiple item measures [46–48]. The three items of our study met the prerequisites of usage of single items based on the literature [49, 50]: (1) they are concrete and simple, not multifaceted; (2) they relate soundly to the other instruments; (3) they are integral parts of (the second and third) research questions; and (4) they fit in our sample consisting of young children who are most likely impatient and not willing to answer many extra questions that only slightly differ from each other.

2.3.6. Experienced Effectiveness of Hands-On on Learning. This variable in pre- and posttest was based on a single question. The question was, *What do you think of the statement*? The statement was, *By hands-on experimentation and testing I can learn effectively*. The scale ranged from 1 (not agree at all) to 5 (totally agree).

2.3.7. Exhibition Enhances My Science and Technology Attitudes. This variable was based on a single question. The question was, *What do you think of the statement*? The statement was, *Due to the math exhibition my attitudes toward science and technology changed in a more positive direction*. The scale ranged from 1 (not agree at all) to 5 (totally agree).

2.3.8. Exhibition Affected My Future Educational Plans. This variable was based on a single question asking about educational plans in general. The question was, *What do you think of the statement?* The statement was, *I believe that the math exhibition influences my future educational plans*. The scale ranged from 1 (not agree at all) to 5 (totally agree).

2.4. Data Analysis Methods. The mean differences and the change between the pre- and posttest were analyzed by General Linear Modeling (GLM; univariate, multivariate, and repeated measures) method. The effect-size measure was partial η^2 coefficient (η^2 > .01 small, >.06 middle, and >.14 large), which is as acceptable as the recommended generalized coefficient when only one grouping factor is used [41]. Graphical plots were used, as recommended, to illustrate the pre- and posttest levels and the change between the pre- and posttest [51].

To answer the third research question and to see how our data would fit in the theoretical model, we applied SEM, the structural equation modeling (AMOS 22). The *RAI*, *gender*, *RAVEN*, *math grade, belief of hands-on effectiveness on learning T1, and math worth T1* were used as covariates to control their effects on measured posttest variables. The goodness of fit of the models was based on a χ^2 test (p > .05) and indices of NFI, TLI, and CFI (good fit >.90, or better > .95), RMSEA reasonable fit < .08, good fit < .05 [52]. The predictors were indicated by standardized β-coefficients, and R^2-multiple correlation indicated the total variance explained.

For testing the invariance of the models across genders and across math achievement quartiles, the unconstrained and fully constrained overall models were compared and the invariance was evaluated based on the χ^2 test.

2.5. Missing Values. There were on average 6% missing values. The maximum likelihood method and estimation of means and intercepts were used in the SEM path analysis due to the missing values.

3. Results

In Tables 1 and 2, we present the statistical descriptors of the variables and the significant differences between the boys and girls and between the math achievement percentiles. In addition, the overall and between-group change are explained in regard to the pretest situation and posttest situation.

3.1. Math Achievement. The overall mean of *math* was 8.19 (SD = 1.138). The difference between girls (M = 8.28, SD = 1.083) and boys (M = 8.09, SD = 1.194) was nonsignificant

Table 1: Statistical descriptors by gender.

	N girls	Mean	Std. dev.	*N* boys	Mean	Std. dev.
RAVEN	134	37.060	6.600	122	36.246	8.454
RAI	132	.107	1.963	120	−.196	1.557
Math grade	131	8.282	1.083	116	8.095	1.194
Math at school	133	3.359	.599	121	3.324	.804
Math at exhibition	119	3.327	.601	107	3.268	.734
Situation motivation	120	3.143	.717	106	3.118	.817
Math worth Time 1	132	3.617	.888	122	3.537	.960
Math worth Time 2	133	3.584	.818	122	3.523	.878
Hands-on I learn effectively Time 1	132	4.061	.914	121	3.860	1.128
Hands-on I learn effectively Time 2	133	3.805	.981	119	3.849	1.110
Exhibition enhanced science & technol. attitudes	119	2.647	1.038	105	2.895	1.126
Exhibition influenced future educational plans	121	2.174	1.070	106	2.302	1.088

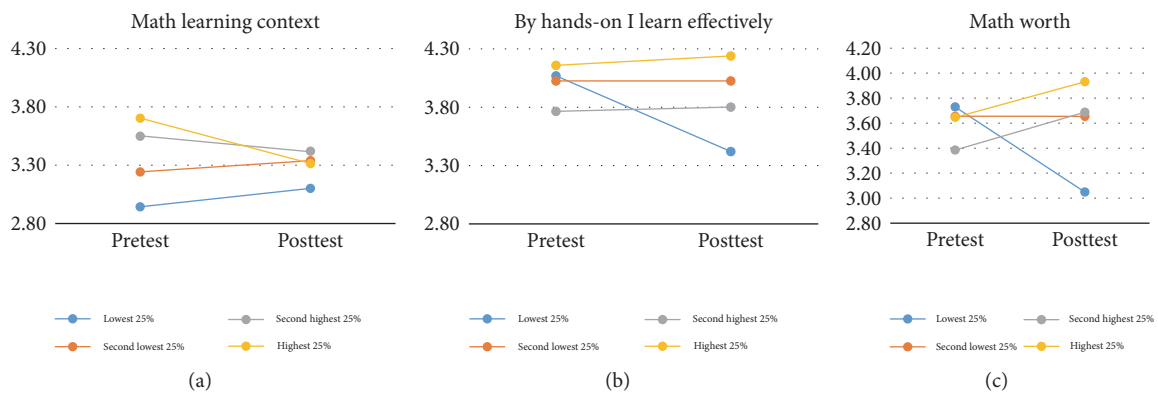

Figure 1: Liking of *math learning in the school context* and *in the exhibition context* (a); *by hands-on I learn effectively* T1 and T2 (b); and *math worth* T1 and T2 (c) by math achievement quartiles.

(p = .197) (note: mean is abbreviated as M and standard deviation is abbreviated as SD)

3.2. Learning Math in School Context and in Exhibition Context. The mean of *liking math learning in the school context* and *liking it in the exhibition context* was rather good on the absolute Likert scale (see Table 1). The differences between the genders were nonsignificant in both contexts (*school context*, p = .213; *exhibition context*, p = .807). The difference between the math achievement quartiles, however, was significant in *school context* (F(df = 3) = 11.933, p = .000, *partial* η^2 = .144; large effect size, lowest quartile versus third and highest quartiles, p = .000; second quartile versus third quartile, p = .023; and fourth quartile, p = .015), but nonsignificant in *exhibition context*, p = .086.

Clearly, the math achievement quartiles differed *in the change* (measured by GLM repeated measures method) from the math *learning school context* to the math *learning exhibition context* (*Wilks' lambda* = .949, F = 3.851, df = 3, p = .010, *partial* η^2 = .051). The change of the highest math achievement quartile was different from the lowest (p = .001), the second highest from the lowest (p = .000), and the second lowest from the lowest (p = .033). The drop in the two highest percentiles was significant.

We illustrate the results by graphs. *Liking math learning in the school context* and *liking math learning in the exhibition context* by math achievement quartiles are presented in Figure 1(a).

3.3. By Hands-On I Learn Effectively. The means of *by hands-on I learn effectively* T1 and T2 were good in the scale 1–5 (see Table 1). The overall change between *by hands-on I learn effectively* T1 and T2 was shown to be nonsignificant. However, the change was significant in the girls' group (*Wilks' lambda* = .970, F = 4.083, df = 1, p = .045, *partial* η^2 = .030; M1 = 4.061, SD1 = .918; M2 = 3.809, SD2 = .970) but not in the boys' group, p = .859 (M1 = 3.864, SD1 = 1.124, M2 = 3.839, SD2 = 1.109); see Figure 2.

The time and interaction effect with the math achievement quartiles was significant (*Wilks' lambda* = .963, F = 3.019, df = 3, p = .031, *partial* η^2 = .037). The change was significantly different between the lowest and highest quartiles (p = .041). Before the math exhibition, the lowest achievement quartile pupils did not differ in *by hands-on I*

Table 2: Statistical descriptors by school achievement quartiles (Ach1: lowest achievement quartile; Ach4: highest achievement quartile).

	N Ach1	Mean	Std. dev.	*N* Ach2	Mean	Std. dev.	*N* Ach3	Mean	Std. dev.	*N* Ach4	Mean	Std. dev.
RAVEN	61	33.049	8.778	51	36.098	7.167	73	38.315	5.580	63	39.492	5.755
RAI	58	−.230	1.765	50	−.254	1.846	73	.022	1.645	63	.231	1.897
Math grade	60	6.800	.860	51	8.078	.744	73	8.521	.626	63	9.238	.640
Math at school	59	2.984	.811	51	3.488	.654	73	3.397	.543	63	3.568	.558
Math at exhibition	49	3.160	.710	43	3.481	.794	68	3.242	.542	58	3.383	.571
Situation motivation	50	3.033	.825	43	3.283	.881	67	2.999	.664	58	3.245	.707
Hands-on I learn effectively Time 1	58	4.138	.945	51	4.000	1.020	73	3.753	1.128	63	4.016	.992
Hands-on I learn effectively Time 2	59	3.593	1.069	51	3.961	.999	71	3.775	1.149	63	4.016	.871
Math worth Time 1	59	3.703	.974	51	3.729	.816	73	3.379	1.003	63	3.596	.826
Math worth Time 2	60	3.201	.867	51	3.727	.864	73	3.503	.877	63	3.813	.643
Exhibition enhanced science & technol. attitudes	48	2.646	1.120	43	3.093	1.042	66	2.652	1.060	59	2.831	1.085
Exhibition influenced future educational plans	49	2.408	.977	43	3.093	1.042	66	2.652	1.060	59	2.831	1.085

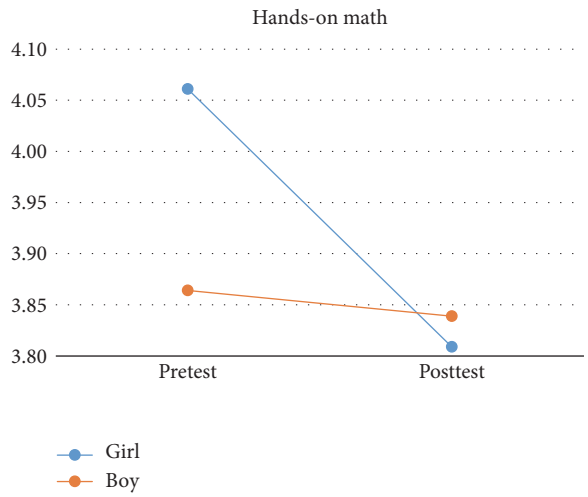

Figure 2: *By hands-on I learn effectively*, pre- and posttest plots by gender.

learn effectively from the other groups ($p = .121$), but the mean decreased significantly in the lowest group after the exhibition (see Figure 1(b)).

3.4. Math Worth. The statistical descriptors are presented here. The mean of math worth at both time points was rather good on the absolute Likert scale (see Table 1).

Changes from Pretest to Posttest. The overall change in experienced math worth was shown to be nonsignificant, and there was no difference in that regard between the genders. However, in regard to between the math achievement quartiles, the change was significant with a middle size effect (*Wilks' lambda* = .903, $F = 8.574$, df = 3, $p = .000$, *partial* $\eta^2 = .097$). The change was significantly different between the lowest and highest quartiles ($p = .043$). Before the math exhibition, the lowest achievement quartile valued math significantly more than after the math exhibition, having a large effect size (*Wilks' lambda* = .741, $F = 19.941$, df = 1, $p = .000$, *partial* $\eta^2 = .259$). The mean increased in the highest and second highest quartile but was significant only in the last mentioned (*Wilks' lambda* = .944, $F = 4.689$, df = 1, $p = .033$, *partial* $\eta^2 = .05$); see Figure 1(a).

3.5. SEM Path Analysis. The relative autonomy index (RAI), gender, cognitive visual reasoning (RAVEN), math achievement, math worth T1, and *by hands-on I learn effectively* T1 were used as covariates to control their effects on the measured variables (*situation motivation; exhibition enhanced my science and technology attitudes;* and *exhibition affects my future educational plans*). The final model containing only significant effects was shown to fit the data well: $\chi^2 = 32.928$, df = 39, $p = .742$, NFI = .941, TLI = 1.021, CFI = 1.000, and RMSEA = .000.

The final path model is presented in Figure 3. The magnitude of the paths (the standardized beta-coefficients) is shown with the indicators of significance ($^{*}p < .05$, $^{**}p < .01$, and $^{***}p < .001$) and the total explanation by R^2.

In the following, first, the effects of the covariates are explained.

(1) After being controlled by other variables, of which only math grade was significantly correlated, *visual reasoning* predicted "*exhibition enhanced my attitudes to science & technology*."

(2) *Math achievement* directly predicted *by hands-on I learn effectively T2, math worth T2*, and to a smaller degree *exhibition influences my educational plans*. In addition, math achievement indirectly predicted *math worth T2* and *situation motivation*. The invariance test was applied using math achievement quartile groups as the moderator. The test showed that the models were invariant (*chi-square* difference = 41.916, df = 33, $p = .137$).

(3) *Autonomous motivation* directly predicted *situation motivation*. Indirectly *by hands-on I learn effectively T2* predicted *math worth T2*, "*Exhibition enhanced my attitudes towards science and technology*," and "*Exhibition influences my educational plans*."

(4) *By hands-on I learn effectively T1* correlated with *math worth T1*. It did not predict any of the measured variables, not even *math worth T2*.

(5) *Math worth T1* predicted *Exhibition enhanced my attitudes toward science & technology* and *Exhibition influences my educational plans*, the last mentioned also indirectly.

(6) *Gender* predicted only one variable: *Exhibition enhanced my attitudes toward science & technology*.

Further invariance tests gender as the moderator allowed to examine that in more detail. The test showed that the models were noninvariant (*chi-square* difference = 21.202, df = 13, $p = .069$); thus, the same model did not fit for both boys and girls. Hence, the analysis continued path by path. The analysis revealed that the two paths differed, and in both cases the connection was stronger among girls than among boys: (1) path from *situation motivation* to *Exhibition enhanced my attitudes toward science & technology T2* ($z = 2.396$, $p < .05$;

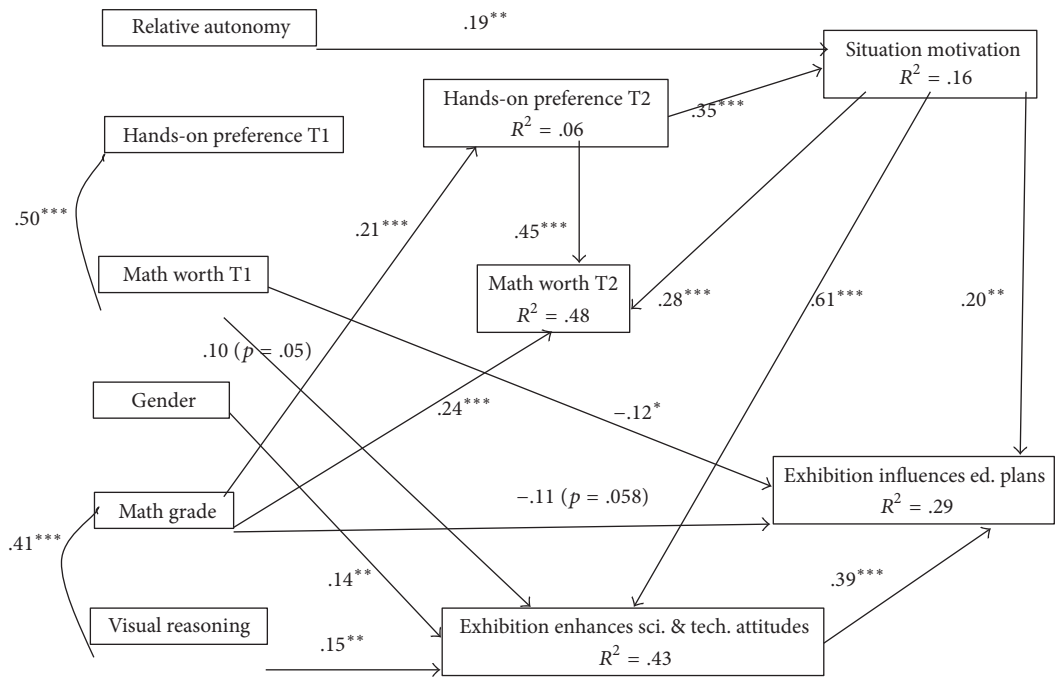

Figure 3: The final path model (* $p < .05$; ** $p < .01$; *** $p < .001$).

girls, std. $\beta = .73$; boys, std. $\beta = .51$) and (2) connection from *situation motivation* to *math worth T2* to *Exhibition enhanced my attitudes toward science & technology T2* ($z = 2.431$, $p < .05$; girls, std. $\beta = .40$; boys, std. $\beta = .17$).

In the following, the effects of and on the posttest variables are explained.

(1) *By hands-on I learn effectively T2* had an effect on *math worth T2 and situation motivation* and indirectly also on *Exhibition enhanced my attitudes toward science & technology* and *Exhibition influences my educational plans. By hands-on I learn effectively T2* was explained by 6% by math grade.

(2) *Situation motivation* had an effect on *Exhibition enhanced my attitudes toward science & technology, math worth T2,* and *Exhibition influences my educational plans*, with the last mentioned being affected also indirectly. The other variables, *autonomous motivation and by hands-on I learn effectively T2* directly explained 16% of *situation motivation*.

(3) The variables of the model explained 48% of experienced *math worth T2*, but its effects on other variables (i.e., *Exhibition enhanced my attitudes toward science & technology* (std. $\beta = .04$) and *Exhibition influences my educational plans*) did not reach significance.

(4) *Exhibition enhanced my attitudes toward science & technology* had an effect on *Exhibition influences my educational plans*. The variables, which contributed to the explanation of its variance, *visual reasoning, gender, math worth T1*, and *situation motivation*, explained 43% of it.

(5) *Exhibition influences my educational plans* was explained with 29% by other variables, *math grade, math worth T1*, and *situation motivation* and, in addition, indirectly by *autonomous motivation* and *by hands-on I learn effectively*.

4. Discussion

4.1. Yes, They All Liked Math, but Interestingly the Lowest Math Achievers Prefer Learning at the Exhibition. First, we have to add that in this kind of research design we cannot claim that the changes in any of the variables are due to one short science exhibition visit; there are lots of possible uncontrollable factors involved. However, we report both what was before the exhibition and how the variable values changed following the exhibition. We consider that the exhibition is one option as it was a planned educational experience that was comprised of elements that have shown to be related to effective learning. The first research question asked how the pupils experienced learning of mathematics in the school context compared to the exhibition context. It was a positive result that both means of *liking math learning at school* and *liking math learning at exhibition context* were rather good on the absolute Likert scale *at school*, meaning that in general pupils liked learning math independent of the context. Like/dislike results can be reflected against international results, which have shown that overall 15 to 22% of pupils dislike mathematics [5].

Based on the data, the math grades of boys and girls were equal. The math achievement result parallels the results of the TIMSS 2015 study in which gender equity of fourth-graders' math results was found in half of the 49 participating countries. However, Finland actually belonged to the minority in TIMMS, with girls outperforming boys. It was interesting to note that both girls and boys also equally appreciated math learning at school and at the exhibition.

However, the experiences were different when it came to math achievement grouping. It was clear that the lowest achieving group appreciated the exhibition alternative for

math learning compared to learning math at school. This makes sense from the cognitive perspective as, according to Oppenheimer [9], manipulation of materials supports understanding abstract mathematical concepts and makes math more meaningful, which is especially shown to benefit diverse learners [15, 18]. From an emotional perspective, the different kind of learning context might promote a decrease of anxiety, which has been shown often to be related to math learning and to the manipulating of numbers and problem-solving, which may be especially so for students with mathematical learning difficulties [16]. But even at school they did not dislike it, as their average 3.01 was just in the middle of the 1–5 scale. At school, they liked math learning least of all the groups but closed the gap later; at the exhibition, they liked math learning as much as the others. However, the gap closing between the math percentiles was partly due to the highest achieving group's drop in liking math learning at the exhibition compared to learning at school and to a smaller degree due to the second highest group's smaller drop. So they, in turn, did not appreciate the exhibition alternative as much as the learning at school. One reason, at least for some of them, might be in the novelty of the situation, which provides a risk: one cannot safely repeat learned strategies and must thus face also a possibility of failure. According to Mofield et al. [14], this kind of situation can prevent those high-achieving students with a high degree of perfectionism from reaching their full potential. Although Mann [12] observed that math achievement has been shown to be an important predictor of mathematical creativity, the majority of the variance remained unexplained in his model, which also applies to other results, which indicates that math achievement is not always connected to math creativity [13].

4.2. Beliefs before and after the Exhibition: Distinct Entities, Different Worlds. The second research question was related to the change of experienced worth of mathematics and the change of belief of hands-on effectiveness on one's learning after the exhibition. Combining math learning with experimentation and art in a concrete model building process in the exhibition was a many-sided and versatile approach. In this study, pupils in average believed before and after the exhibition that they learn effectively by hands-on method. It was baffling and unexpected after just a short exhibition visit that based on the SEM-model the belief was not stable from the pretest to the posttest belief after the exhibition, in SEM-technical language: the pretest did not predict the posttest. Similarly experienced worth of mathematics was not stable but differed in the posttest situation. These results point in the same direction as Burn's and Silbey's findings [53]: there is a risk that pupils do not see the connection between the different learning contexts of the traditional classroom and the out-of-school exhibition. In the context of the Math and Art Exhibition, this phenomenon turned out to be a conflict between hands-on learning and the traditional pencil-and-paper method at school.

The experience of hands-on effectiveness on learning at the school and at the exhibition was not consistent across the subgroups. Boys felt to an equal degree that the method was effective in both contexts. However, in turn, that belief plummeted among the girls. Previous studies have found that boys tend to prefer hands-on approach over other kinds of methods, at least in science learning [37, 54]. The experienced worth of doing math did not differ between genders.

There was also a drastic drop in the belief of the lowest math achievement quartile of the hands-on methods' effectiveness on their learning, and there was a similar one in their belief in the worth of math. So, they appreciated the opportunity to do something differently as was shown by the comparison of the math learning context at school/at the exhibition, but at the same time they somewhat lost belief in their ability to take advantage of its possibilities, meaning the hands-on and art combination and problem-solving by building the models. They also began to hesitate about the worth of mathematics, which included whether or not mathematics could make their everyday life easier, its usefulness in working life, the importance of understanding mathematical phenomena, and whether mathematics is interesting at all. The higher achievers kept their belief in the hands-on effectiveness of learning despite the result that the higher achieving groups did not like the change of learning context from the school to the exhibition. The worth of math, in turn, increased in the two highest math achieving percentile groups.

4.3. Situation Motivation: A Powerful Attitude Booster Especially among Girls. The third research question related to situation motivation's and other variables' role in change of attitudes toward science and technology and future educational plans. We found that situation motivation was the most powerful explainer especially in regard to the experienced exhibition influences on science and technology attitudes, and it also affected future educational plans. These results imply increased metacognition, the awareness of what one thinks and plans, like Lai et al. [16, p. 2] observed: "Motivation is an important energizing factor of metacognition and can activate the self-regulation process."

Situation motivation was boosted by relative autonomy experience. The previous results relating to differences between genders in autonomous motivation are mixed; some have found differences [54]; some have not [37, 54]. In the present study, the difference in autonomous motivation experience was nonsignificant between the boys and girls. Hence, in both groups, it equally predicted situation motivation. Overall, the pupils experienced themselves as nonautonomous because the RAI remained negative. In order to enhance situation motivation and, indirectly, the future plans, more degrees of freedom most likely would have been beneficial. The results in science learning context by Jalil et al. (2009) support this [55]. Also, experienced hands-on effectiveness of learning enhanced situation motivation—pupils who preferred that method found the exhibition, with its experimenting and model building, more attractive.

The experienced positive science and technology attitude change influenced future educational plans of the students most strongly. The boys experienced more than the girls that the exhibition was useful and fostered their science and technology attitudes. On the other hand, boys and girls did not

differ in situation motivation, but based on the path-by-path comparison due to the significant result of using gender as the moderator, the experienced attractiveness of the exhibition among girls was much more strongly connected to the science and technology attitudes than among the boys. Similarly, situation motivation enhanced the experienced worth of mathematics among girls more than among boys. These are important results, revealing more specifically attributes of motivation, science and technology attitudes, and their connection to future educational aspirations. For their part, the results answer Osborne et al.'s [2003, p. 1] call for research [56]: "The literature itself points to the crucial importance of gender and the quality of teaching. Given the importance of the latter we argue that there is a greater need for research to identify those aspects of science teaching that make school science engaging for pupils." The answer is to bring motivational, concrete, and creative elements from the informal STEAM exhibitions to school and, thus, narrow the gap between traditional and experimental teaching. The researchers agree with the need for enhancing creativity in math education at school [cf. [12, 13, 57]].

The math grade and the question of the worth of mathematics asked before the exhibition predicted how pupils experienced the effect of the exhibition on their educational plans. These direct effects were negative, which implies that those who were not high achieving and who did not believe in the worth of mathematics before perceived more positively the effect of the exhibition on their attitudes toward science and technology and their educational plans than the others. However, it is worth noting that the others might already have had positive attitudes and simply did not believe that the exhibition had changed them.

Math achievement and the worth of mathematics before the exhibition had as well, however, a positive, indirect role on the plans either via situation motivation or via change of science and technology attitudes. This means that the higher the math achievement or experienced mathematics worth is, the more positive the attitudes were and the more the exhibition was believed to enhance the educational plans. Similarly, the experienced effectiveness of hands-on method on learning in the exhibition and autonomous motivation affected the attitudes and plans positively.

As already mentioned in relation to the answer to the second research question, the experienced worth of mathematics before and that after the exhibition were found to be quite separate entities. The latter did not seem to have any relevance in the minds of pupils in this context, as it did not predict the science and technology attitudes or the educational plans.

Based on the RAVEN test theory, boys and girls did not differ in the cognitive, visual reasoning test. Visual reasoning predicted the experienced exhibition influences on the science and technology attitudes but indirectly also on future educational plans.

5. Conclusions

In this article, art was combined with math. The learning context was the Math and Art Exhibition. The main results of this study support the earlier key findings of motivation and learning reported in the literature [58, 59]. In the exhibition, hands-on math learning was mixed with art by workshop, which allowed the pupils to build mathematical structures. This creative component was to provide an esthetic experience via shaping the beauty and sense of wholeness and aimed to lead to more effective math learning. Thus, building the models was about art and artistic and technical skill and was also an emotional process, especially because cooperation with others in building the models was fun. Based on learning research [15, 30, 60], hands-on learning and involvement of positive emotions lead to deeper learning and a better retention of the matter learned. Earlier findings of the learning outcomes of the Math and Art Project support this [32].

One of the most interesting and encouraging results of this study was that the lowest achievers liked learning math in the exhibition context, and they preferred it over the school context. This is in line with some recent results relating to a dinosaur exhibition and the use of AR (Augmented Reality) in informal learning [61]. However, these results contradict the earlier reports in the literature [cf. [62]], which indicates that the high achievers benefit from the informal learning settings like science center exhibitions most of all.

The fact that the present study shows that the high achievers preferred the school context is curiosity provoking and gives cause for further consideration. In the next part, we explore possible reasons for the results by using Brady and Kumar's [63] "motive of inventor" and Sternberg's [64] view of creativity as the reflection surface. It is interesting to consider what the role might be of emotions such as math anxiety, fear of a challenge, or the excitement of breaking an old habit in a novel learning situation that the pupils face in the informal math exhibition.

5.1. "Motive of Inventor" by Brady and Kumar [63]. Because math problems were approached from a new perspective, one could not anymore self-evidently operate or think as before. Instead, the math and art experience might have led to a reconceptualization of math being a formal, solidified, difficult school subject, which is hard to approach and learn. The same approach, even just a fun hands-on experiment, did not necessarily fit everybody, as could be hypothesized based on the literature [9, 14].

Some pupils reported that they gained from the artistic hands-on approach in the exhibition, and they might be characterized as creative individuals that Sternberg [64] describes "are willing to go their own way." Further, Sternberg [64] states they are those who "(a) redefine problems in novel ways, (b) take sensible risks, (c) 'sell' ideas that others might not initially accept, (d) persevere in the face of obstacles, and (e) examine whether their own preconceptions are interfering with their creative process."

On the other hand "the motive of inventor" [63] can have attracted those pupils suffering from math anxiety. The artistic hands-on approach might have been seen as a welcomed relief; that is, instead of "leaning on mathematics of others," a self-initiated inquiry was encouraged [26]. It might have supported pupils to overcome difficulties, which the traditional math teaching at school sometimes can cause,

and it may have been useful to many of those pupils who consider mathematics to be not meant for them.

The same artistic hands-on process might, however, have alienated those who were less flexible. They probably considered that math had lost its worth due to the fun and play aspect experienced at the exhibition and when the subject was within easier reach of everyone.

5.2. Bridging Is Needed for Transfer. One of the most important findings is that there seems to be a hidden risk in the process: the experience of the hands-on effectiveness and worth of mathematics were shown to be distinct entities, and in pupils' minds the school and the exhibition are likely to form quite different worlds. Thus, it is important that the 4D Math and Art Project, as well as other similar projects in the future, does not remain simply as one more fun experience. Instead, it is important that the learned observation and thinking skills transfer into the further mathematical studies of pupils. To ensure this, teachers need to wisely support their pupils to build a bridge and make a connection between learning at the exhibition and learning in the classroom. Further, this will help to find the meaning of the math and art approaches and in the end the meaning of mathematics itself.

All in all, the hands-on and art approach to math involving touching and seeing helped pupils to produce creative results, which otherwise would not have come into the world. In the building project, pupils had to continuously change from the observation of details to observing the whole and back, which prevented pupils from becoming stuck and which supported the testing of ideas and flexible thinking—a prerequisite of development of cognition and creativity. According to Hope [20], the visual representation shows the cognitive learning outcome, the thinking results of the pupils, and how they have found the key spatial characteristics of the problem in concern. One can assume that this kind of process also promotes consciousness and metacognition in students, which are important goals of math education [16]. As such, the next step concerning the project will be most interesting, as we will use video analysis and focus on examination of the building process and the resulting visual models.

In fact, the process of building the hands-on art and math structures resembled a lot the process of computer programming, where everything is based on totally reduced units of 1 and 0. In the 4D Math system, the pupils had only four types of units to create different structures and creatures. Now, bridging the gap between the general mathematical competence and the increasingly computational contemporary culture, the power of curiosity, imagination, and play by Görlitz [4] is forming the link between the real material world and the totally digitalized environments.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Hindawi
Education Research International
Volume 2017, Article ID 4571383, 9 pages
https://doi.org/10.1155/2017/4571383

Research Article

Threshold Effects of Creative Problem-Solving Attributes on Creativity in the Math Abilities of Taiwanese Upper Elementary Students

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Received 23 March 2017; Revised 4 July 2017; Accepted 2 August 2017; Published 19 September 2017

Academic Editor: Kirsi Tirri

This study aimed to help determine what the typology of math creative problem-solving is. Different from studies that have discussed the threshold effect between creativity and intelligence, this research investigated the threshold effect between creativity and other attributes. The typology of the math creative problem-solving abilities of 409 fifth- and sixth-grade Taiwanese students was identified and compared in this study. A Creative Problem-Solving Attribute Instrument was devised for this study, with the aim of measuring students' perceptions on their motivation, knowledge, and skills, both in general and in specific domains. Divergent and convergent thinking were also measured. Cluster analyses yielded three creative problem-solving typologies: High, Medium, and Low. The High Attribute group scored significantly higher in the Math Creative Problem-Solving Ability Test than did the Medium Attribute and Low Attribute groups. The results suggest a threshold effect from several attributes—divergent thinking, convergent thinking, motivation, general knowledge and skills, domain-specific knowledge and skills, and environment—on students' creative problem-solving abilities. Balanced development of attributes may be an important consideration in nurturing creativity in children.

1. Introduction

Creative problem-solving is crucial for the improvement of society and is also important for the activities we do in our daily lives [1, 2]. Additionally, creativity and the ability to solve problems creatively are considered essential skills that future talent must be equipped with [3]. In this study, creativity is a necessary component of creative problem-solving ability. It is therefore necessary to characterize the relationship between problem-solving (in general) and creativity. Creativity can be part of problem-solving [4–7]; it is especially so when solutions to problems are not easily reached or readily available and when the ideas required for solutions are novel and are particularly appropriate to solving the problems [8, 9]. Some researchers believe the process of creativity actually constitutes the whole of the problem-solving process, from problem finding to executing a plan [10]. Guilford [11] associated creativity with problem-solving and identified four stages of the creative process: (1) recognition of an existing problem; (2) production of a number of relevant ideas; (3) recognition of various possibilities produced; and (4) the drawing of appropriate conclusions that lead to the solution. Houtz [12] believed that Torrance's definition of creativity, defined as "the process of sensing gaps or disturbing, missing elements; forming ideas or hypotheses concerning them; testing these hypotheses and communicating the results, possibly modifying and retesting the hypotheses" [13, p. 16], is similar to the process of problem finding and problem-solving, because creativity can be exercised while solving open-ended and ill-defined problems.

It is believed that creative problem-solving ability is difficult to research and that it is difficult to put the results of that research into practice [14]. Various measures of creativity tend to have different operational definitions, and the attributes of creativity continue to be debated. During the early development of creativity research, the structure of creativity was measured via divergent thinking tests and has gradually come to be equated with divergent thinking [11, 13]. However, divergent thinking tests have been evidenced to have poor reliability and weak predictive validity [15].

Additionally, in some studies, the structure of creativity has been understood as an entity independent from academic achievement, which implies that knowledge and skills learned in school are not necessary in exercising creativity [15–18]. However, with the emergence of the theory of domain specificity of creativity, the importance of knowledge and skills within specific domains has come to be recognized among researchers on creativity [19–21].

The foundation of this research is based on the belief that creativity is multifaceted and complex, and this belief has been evidenced in recent research [20, 22–29]. Guilford [22] claimed that several factors are involved in creative thinking: (a) sensitivity to the problem; (b) fluency; (c) novelty; (d) flexibility; (e) ability to synthesize; (f) analytical ability; (g) reorganization or redefinition; (h) complexity; and (i) evaluation. Torrance [28] discussed the multifaceted nature of creativity, defining creativity as "the process of sensing difficulties, problems, gaps in information, missing elements, something askew; making guesses and formulating hypotheses about these deficiencies; evaluating and testing these guesses and hypotheses; possibly revising and retesting them; and finally communicating the results" (p. 47). Amabile [20, 23] suggested a Componential Model of Creativity, which includes domain-relevant skills, creativity-relevant skills, and task motivation. Csikszentmihalyi [17] proposed six personal resources for producing creativity: intelligence, knowledge, styles of thinking, personality, motivation, and environmental context. Urban's [29] component model of creativity views the creative process as containing six components: (1) divergent thinking and acting; (2) general knowledge and base for thinking; (3) specific knowledge base and specific skills; (4) focus and task commitment; (5) motivation and motives; and (6) openness to and tolerance of ambiguity.

Cho [24, 30] proposed six attributes of creative problem-solving ability: divergent thinking; convergent thinking; motivation; general knowledge and skills; domain-specific knowledge and skills; and environment, in her Dynamic System Model of Creative Problem-Solving Ability, which was based upon Csikszentmihalyi's [17] complex model of creativity and Urban's [29] Componential Model of Creativity. Knowledge and skills provide individuals with preliminary resources in which divergent and convergent thinking either evaluate or search for alternatives [31, 32]. Divergent thinking is used to search for alternatives. Convergent thinking is used to evaluate various alternatives against criteria and to correct errors in order to achieve the best answer to the problem [21, 33, 34].

Cho suggested that creative problem-solving ability functions like an organic system whose attributes dynamically interact to solve a problem, where motivation, general knowledge and skills, and domain-specific knowledge and skills form the bases of creative problem-solving. Convergent and divergent thinking function as tools that utilize domain-specific and general knowledge and skills in order to solve problems in a new and useful fashion. Creative problem-solving ability can grow or diminish, depending on the micro- and macro-environmental conditions of the external organic systems individuals find themselves in. In addition, if any of the attributes are not developed to the necessary level, creativity will not blossom. Cho's model is the theory upon which this study is founded.

The threshold effect is one of the essential topics discussed in creativity research, and the correlation between creativity and intelligence is also often investigated. Creativity and creative problem-solving have also been stated to be related to intelligence [21]. The theory of the threshold effect for intelligence and creativity was first proposed by Guilford, who stated that creativity is well-predicted at IQ levels below 120 but not above 120 [21]. However, even when creativity is recognized as multifaceted and cannot be simply determined by a single factor, the threshold effect theory has merely been studied as it relates to intelligence and creativity but not applied to the correlations between creativity and other attributes. Torrance [13] claimed threshold effects in intelligence, but such effects have not yet been verified for other attributes of creativity.

In this study, the Creative Problem-Solving Attributes Inventory (CPSAI) was developed by combining Cho's dynamic system model [23, 24, 30] and Treffinger's CPS Model Version 4.0 [35, 36] as frames of reference. Version 4.0 of Treffinger's CPS emphasizes a three-stage process of solving problems creatively, where divergent thinking and convergent thinking are both utilized at each stage [35, 36]. The three overall stages of the CPS process are as follows: understanding the problem (mess-finding, data-finding, and problem finding); generating ideas (idea-finding); and planning for action (solution-finding and acceptance-finding) [37]. Although it is not the latest version, CPS Version 4.0 clearly describes the creative problem-solving processes that young students, who are relatively inexperienced real-life problem solvers, might experience. It also does so in a less complex manner than is detailed in CPS Version 6.1, the latest one.

The main purpose of this study was to shed light on the essential attribute(s) of creative problem-solving ability in math, as based on Cho's theory. Most importantly, the study aimed to investigate whether there is a typology, or even a threshold effect, between creative problem-solving and a variety of attributes, among different levels of creative math problem-solving ability. This study aimed to provide insight into how best to nurture creativity.

2. Materials and Methods

2.1. Sample. A total of 409 fifth and sixth graders were recruited from two elementary schools in Taiwan. Because there is a minimum age requirement for Taiwanese students to enroll in elementary school and there is no accelerated program at the elementary level, fifth- and sixth-grade students' ages generally range from 10 to 12 years. 325 students (54.8% males and 45.2% females) were sampled from School A. In School B, a sample of 84 students (60.7% males and 39.3% females) participated. Demographically, these participants came from two-parent households (96%), were born in Taiwan (99%), and mainly spoke either Mandarin (59%) or Taiwanese (37%) at home.

2.2. Research Questions. The following research questions were addressed in this study:

(i) How are the proposed attributes in Cho's theory related to corresponding attributes assessed by other established measures (e.g., the Creativity Assessment Packet, Critical Thinking Test, and Inventory of Parental Influence)?

(ii) What are the distinctive patterns of attribute combinations for creative problem-solving ability evidenced among fifth- and sixth-grade Taiwanese students?

(iii) After categorizing the respondents into three different groups based on their responses to the CPSAI, what were the differences between these three groups, in terms of their math creative problem-solving performance?

2.3. Instruments. The CPSAI is an instrument that measures students' self-perceptions of five attributes of creative problem-solving ability. To examine its structural validity, four other instruments were also administered: the Math Creative Problem-Solving Ability Test [26]; the Creativity Assessment Packet [38]; the Critical Thinking Test-I [39]; and the Inventory of Parental Influence [40]. The validity and reliability of each instrument are described below.

The CPSAI. The CPSAI is a self-report questionnaire in which students rate their frequency of using attributes of creative problem-solving, by responding to 41 items on a scale from 1 *(Hardly Ever)* to 5 *(Very Often)*. The theoretical basis of the CPSAI is adopted from Cho's Dynamic System Model of Creative Problem-Solving and Treffinger's Creative Problem-Solving [23, 35]. There are five subscales included: Divergent Thinking; Convergent Thinking; Motivation; General Knowledge; and Environment. In each of the five subscales, the test questions describe possible behaviors for creative problem-solving attributes that can be exhibited during each stage of creative problem-solving. For instance, items in the *Divergent Thinking* subscale describe divergent thinking-related behaviors in the stages of problem finding (e.g., "I ask many related questions when I try to understand problems"), generating ideas (e.g., "I get many different ideas by thinking from different standpoints"), and planning for action (e.g., "I have several different procedures to solve problems").

Because the CPSAI is a new measure and the Math Creative Problem-Solving Ability Test (MCPSAT) is a slightly modified version of the original, these instruments were first piloted over a one-month period to establish reliability. Detailed information about the MCPSAT can be found in the next paragraph. The pilot group consisted of 74 students (31 fifth graders and 43 sixth graders) from various backgrounds, recruited from several private institutions across Tainan City and Tainan County. Cronbach's alpha for the test items showed reasonable internal-consistency on the subscales of *Motivation* (α = .80), Environment (α = .88), *Divergent Thinking* (α = .89), and *Convergent Thinking* (α = .94) but only minimally adequate reliability on the subscale of *General Knowledge and Skills* (α = .65).

Table 1: Internal validity of the MCPSAT by item relevance indexes and item difficulty level.

Item	1	2	3	4	5	6	7	8	Mean
Infit MnSq	.91	1.19	1.15	.87	1.12	.90	1.65	2.06	1.23
Outfit MnSq	.87	1.05	1.01	.86	.93	1.13	.99	2.06	1.11
Difficulty	−.63	−.49	−.37	−.42	−.11	.53	.74	.76	.00

The Math Creative Problem-Solving Ability Test (MCPSAT). The MCPSAT is a creative problem-solving ability assessment of open-ended math problems that identifies gifted students in math [25]. Students' responses were evaluated in terms of fluency, flexibility, and originality [26]. Fluency is scored according to the number of correct answers to the problems. Flexibility is scored by the number of categories of correct answers produced for the problems. For instance, one of the questions is, "Using the following equation ($77 \times 15 = 1155$), please create up to 10 new equations." If a student's answer includes $15 \times 77 = 1155$ and $\sum_{i=1}^{15} 77$, this would be considered as two different categories. Originality is scored by how frequently a student's given correct answer to a question was provided by the other students (i.e., more frequent answers equal lower originality). A rubric with exemplary answers for each score ranking was developed by selecting and classifying all relevant responses to each question. The members of the research team discussed and revised the evaluation rubrics when faced with unique and challenging responses. Participants' responses were scored by math teachers who have been trained on the nature of the problems and on possible answers for each test item. Taiwanese math teachers reviewed the problems in terms of their difficulty, with comparative reference to the Taiwanese math curriculum, and noted students' difficulties during the pilot testing, resulting in the selection of eight problems (five *easy* items, two *medium* items, and one *difficult* item) for the final version of the MCPSAT for the study.

Statistical analyses were performed to examine the following aspects of the MCPSAT with regard to the current participants: internal-consistency reliability; internal validity; and difficulty level. Reliability, measured by internal-consistency, of the MCPSAT was found to be reasonably good, since Cronbach's alpha for the eight test items was .73. The internal validity of each test item was calculated using BIGSTEPS, and an item analysis was conducted based on Rasch's 1-parameter item-response model. The analysis model used in this study was the Partial Credit Model. The value for item 8 exceeded 2.0, which indicated low internal validity (see Table 1). Aside from item 8, all other internal validity indexes were less than 1.2. The overall fit statistics confirmed that the internal values of the items were high enough to be good. In this study, the item difficulty was calculated based on Rasch's 1-parameter item-response model. An item difficulty of 0.0 indicated average item difficulty. The higher the value, the more difficult the item. Results showed that the logit scores of items 7 and 8 were the most difficult items

(see Table 1) and that the test items had been distributed from easy to difficult. Additionally, when all the items are distributed equally from easy to difficult, the ordering of the problems itself may motivate the participants to attempt and complete all of the problems in the instrument, rather than placing more difficult obstacles in their paths earlier on.

The Creativity Assessment Packet (CAP). The original version of the CAP was created by Williams [38]. Its Chinese version was translated and validated by Lin and Wang. The CAP is intended to identify creativity levels among students in grades 4 to 12 [41]. The two subtests of the CAP—the Test of Divergent Thinking (TDT) and the Test of Divergent Feeling (TDF)—were investigated for relationships with the *Divergent Thinking* and *Motivation* subscales measured by the CPSAI, respectively. In the TDT, examinees completed drawing 12 different figures, based on the lines presupplied in each item, and gave titles to their drawings. Their final products were scored based on fluency, flexibility, originality, collaboration, openness, and title. The TDF is a 3-point Likert scale questionnaire that asks students' preference on statements in four subscales: curiosity; risk taking; desire for complexity; and imagination.

In this study, 31 students' responses were randomly selected and rated by an external rater to test the interrater reliability of the TDT, which was found to reach .91. Additionally, the alpha value for internal-consistency was .85 for the TDF and .64 for the TDT. The overall score on the TDT significantly correlated with the subscale scores for fluency ($r = .49$, $p = 0.01$), originality ($r = .58$, $p = 0.01$), openness ($r = .84$, $p = 0.01$), elaboration ($r = .82$, $p = 0.01$), and titles ($r = .60$, $p = 0.01$), but not with flexibility.

The Critical Thinking Test- (CTT-) I. The CTT-I measures critical thinking skills of 5th- to 12th-grade students, with 25 multiple-choice questions that represent five critical thinking skills (Identification of Assumptions; Induction; Deduction; Interpretation; and Evaluation of Arguments) [39]. The test has previously been validated with 2,228 elementary students, and the alpha, using the ITEMAN item analysis, was .76. Cronbach's alpha for each subscale ranged from .32 to .49. Correlations between the overall score and the subscale scores ranged from .23 to .45 ($p < 0.001$). In this study, Cronbach's α of the overall test was .57. The overall score of the CTT-I significantly correlated with Identification of Assumptions ($r = .61$, $p < 0.001$); Induction ($r = .61$, $p < 0.001$); Deduction ($r = .67$, $p < 0.001$); Interpretation ($r = .60$, $p < 0.001$); and Evaluation of Arguments ($r = .45$, $p < 0.001$).

The Inventory of Parental Influence (IPI). The IPI is a cross-cultural, self-reported instrument designed to identify students' perceptions of family processes, including parental pressure; support; help; pressure toward intellectual development; monitoring; and communication [40]. A positive family process has been found to significantly influence students' creative problem-solving ability [42]. In addition, support and pressure toward intellectual development have been observed to significantly affect former Science Olympians' academic achievements [42]. Cho and Campbell [42] validated the instrument with 757 past Science Olympians and obtained internal-consistency reliability for the scales of support ($r = .63$) and of pressure toward intellectual development ($r = .80$).

In this study, the relationships between the Environment subscale of the CPSAI and the subscales of Pressure toward Intellectual Development and of Support were investigated. This is because a positive family process, which consists of support and pressure toward intellectual development, is significantly correlated with creative problem-solving in math [43]. In this study, the internal-consistencies of the Support and Pressure toward Intellectual Development subscales were $\alpha = .75$ and $\alpha = .76$, respectively.

In summary, the TDT and TDF subtests of the CAP, the CTT-I, and the IPI were administered to determine whether the attributes measured by the CPSAI subscales are similar to those measured by these established instruments. Scores on general and domain-specific knowledge and skills measured by the CPSAI were compared with students' GPAs and academic achievements, respectively.

2.4. Data Collection. The MCPSAT, CPSAI, CAP, CTT-I, and IPI were administered during two one-hour sessions over two weeks, with the MCPSAT and CPSAI in the first week and the CAP, CTT-I, and IPI in the second week. All instruments were administered by the author, with assistance from teachers at the schools. Students' math achievement test scores, which are administered three times per semester, and GPAs from the previous semester were used as measures of domain-specific and general knowledge and skills.

2.5. Data Analysis. A confirmatory factor analysis was performed to determine if the relationships between the variables in Cho's model resemble the relationships between the variables in the observed data. In addition, internal-consistency between the overall scores and the score for each subscale of the CPSAI items and correlation coefficients among the subscale scores were analyzed. The correlation coefficients between the sub-scores and total score of the CPSAI were computed. Additionally, the scores from the CAP, CTT-I, and IPI were analyzed in comparison with the respective subscales of the CPSAI. A cluster analysis based on participants' responses on the CPSAI was performed to determine the typical typology of creative problem-solving ability in Taiwanese students. An analysis of variance (ANOVA) and follow-up post hoc tests were carried out to investigate the mean differences in the five attributes (divergent thinking; convergent thinking; motivation; general knowledge; and environment) and to investigate differences in the scores on the MCPSAT between the clusters.

3. Results

3.1. Structural Validity and Reliability. Confirmatory factor analysis was conducted to examine if the hypothesized five-factor structure, which was believed to underlie the factors in the CPSAI, fits the data. Hypothesized models were assessed

Table 2: Mean, SD, and n among the students' responses on five subscales and CPSAI total score.

Variables	N	M	SD
Divergent Thinking	359	28.30	8.34
Convergent Thinking	342	22.17	6.63
Motivation	338	19.26	5.58
General Knowledge	335	14.65	5.22
Environment	351	36.40	10.94

by AMOS maximum likelihood factor analysis and evaluated for four measures of fit: (a) chi-square test; (b) Comparative Fit Index (CFI); (c) Normed Fit Index (NFI); and (d) Root Mean Square Error of Approximation (RMSEA).

The *Divergent Thinking* scale showed a good fit (χ^2 = 67.89 (35, 281), $p < 0.001$, CFI = .960, NFI = .923, and RMSEA = .058). The *Convergent Thinking* scale moderately fit the observed data (χ^2 = 77.08 (20, 281), $p < 0.001$, CFI = .935, NFI = .914, and RMSEA = .101). The model for the *Motivation* scale was a reasonably good fit (χ^2 = 15.214 (9, 281), $p = 0.085$, CFI = .983, NFI = .960, and RMSEA = .050). There was a good fit for the hypothesized model for *General Knowledge and Skills* (χ^2 = 4.647 (5, N = 281), $p = 0.460$, CFI = 1.00, NFI = .992, and RMSEA = .000). For the *Environment* scale, the chi-square yielded an undesirable value (χ^2 = 153.121 (44, N = 281), $p < 0.001$), but a moderate fit with the observed data was seen (CFI = .924, NFI = .897, and RMSEA = .094). Overall, the findings of the confirmatory factor analysis yielded a good to moderate fit between the five-factor structure model and the observed data.

Correlation coefficients were computed for the five subscales. Tables 2 and 3 present the means and standard deviations, as well as the correlational analysis in which statistically significant correlations ranged from .45 to .70 ($p < 0.01$). The correlation between the *Divergent Thinking and Convergent Thinking* scales was the highest ($r = .70$, $p < 0.01$). The *Motivation* scale correlated higher with *Divergent Thinking* ($r = .64$, $p < 0.01$) and *Convergent Thinking* ($r = .64$, $p < 0.01$) compared to *General Knowledge and Skills* ($r = .50$, $p < 0.01$) and *Environment* ($r = .55$, $p < 0.01$). In terms of the relationship between the overall CPSAI score and each subscale, *Divergent Thinking* ($r = .84$, $p < 0.001$) and *Convergent Thinking* ($r = .84$, $p < 0.001$) correlated higher with the CPSAI total score, while *Environment* ($r = .80$, $p < 0.001$), *Motivation* ($r = .78$, $p < 0.001$), and *General Knowledge and Skills* ($r = .75$, $p < 0.001$) appeared to be slightly less correlated.

To assess whether the items for each scale yielded reliable data, Cronbach alphas were computed. The alpha values for *Divergent Thinking* ($\alpha = .87$), *Convergent Thinking* ($\alpha = .84$), *Environment* ($\alpha = .89$), *Motivation* ($\alpha = .79$), and *General Knowledge and Skills* ($\alpha = .85$) indicated that their respective items had good internal-consistency. Furthermore, the internal-consistency of the items overall was good ($\alpha = .85$).

3.2. Relationship between CPS Attributes and the Established Instruments. The Pearson correlation coefficients between *Divergent Thinking* and TDT ($r = .15$, $p < 0.01$), *Convergent Thinking* and the CTT-I ($r = .19$, $p < 0.01$), *Motivation* and the TDF ($r = .40$, $p < 0.01$), *Environment* and positive IPI I ($r = .61$, $p < 0.01$), and *General Knowledge and Skills* and academic achievement ($r = .40$, $p = 0.01$) indicated that the scores on the established instruments and academic achievement were related to the scores on the attributes of CPSAI. Medium to large effect sizes were found in the associations. The correlation coefficient between the *Divergent Thinking* scale of CPSAI and the TDT was the lowest. The content of the *Divergent Thinking* scale of the CPSAI measures math problem-solving situations, whereas the TDT measures divergent thinking in drawing figures.

3.3. Differences in Attributes among Different Math Creativity Groups. A hierarchical cluster analysis was performed to identify relatively homogenous groups, based on students' responses in the scales of *Divergent thinking, Convergent thinking, Motivation, General Knowledge and Skills*, and *Environment*. After excluding missing values, 73% of the samples were included in the cluster analysis. Three clusters were found to be the most appropriate, as they yielded the most statistically significant differences among the clusters. These three clusters were eventually (see below) labeled Low, Medium, and High.

A one-way ANOVA was conducted to examine the differences in the five attributes among the three clusters. Levene tests on the first one-way ANOVA were significant for the subscales of *Divergent Thinking* and *Motivation*, which indicated violations of the assumption of homogeneity of variances. Therefore, Games-Howell tests were performed for these two subscales, whereas Tukey HSD tests were conducted for the subscales of *Convergent Thinking, Environment*, and *General Knowledge and Skills*.

Table 4 shows statistically significant differences between the three clusters in *Convergent Thinking* ($F(2, 296) = 166.93$, $p < 0.001$), *Environment* ($F(2, 296) = 173.68$, $p < 0.001$), and *General Knowledge and Skills* ($F(2, 296) = 99.13$, $p < 0.001$). The means for *Convergent Thinking, Environment, General Knowledge and Skills, Divergent Thinking*, and *Motivation* in Cluster 3 were the highest among the three clusters, whereas Cluster 1 showed the lowest means across all five attributes. Post hoc Tukey tests indicated that the mean differences between pairs of clusters were significant in each of these five subscales ($p < 0.05$). Clusters 1, 2, and 3 were labeled as Low Attribute (LA), Medium Attribute (MA), and High Attribute (HA) based on their mean scores in all five subscales (see Figure 1). The High Attribute (HA) group had at least above medium levels in *Divergent Thinking, Convergent Thinking, Environment*, and *General Knowledge*. In addition, the HA students tended to have very high motivation when solving new and difficult problems. On the other hand, mean scores of the Low Attribute (LA) group were the lowest in each subscale among the three clusters. Furthermore, the HA students showed higher scores in *Motivation* than did the MA and LA students.

Table 3: Correlation coefficients between students' responses on five subscales and CPSAI overall score.

Variables	Divergent Thinking	Convergent Thinking	Motivation	General Knowledge and Skills	Environment	CPSAI total score
Divergent Thinking	—	.70**	.64**	.56**	.48**	.84**
Convergent Thinking		—	.63**	.57**	.53**	.84**
Motivation			—	.55**	.50**	.78**
General Knowledge				—	.45**	.75**
Environment					—	.80**
CPSAI total score						—

** $p < 0.01$.

Table 4: One-way analysis of variance results for group differences in Convergent Thinking, Environment, General Knowledge and Skills, Divergent Thinking, and Motivation among the three attribute pattern clusters.

	Cluster	N	M	SD	F	p	Tukey
Convergent Thinking (8 items)	Cluster 1	62	1.93	5.65	166.93	0.000	Cluster 2 > Cluster 1* Cluster 3 > Cluster 1* Cluster 3 > Cluster 2*
	Cluster 2	113	2.54	4.37			
	Cluster 3	124	3.47	4.17			
	Total	299	2.80	6.67			
Environment (11 items)	Cluster 1	62	1.93	6.70	173.68	0.000	Cluster 2 > Cluster 1* Cluster 3 > Cluster 1* Cluster 3 > Cluster 2*
	Cluster 2	113	3.38	7.58			
	Cluster 3	124	3.93	8.05			
	Total	299	3.31	11.18			
General Knowledge and Skills (5 items)	Cluster 1	62	1.93	3.81	99.13	0.000	Cluster 2 > Cluster 1* Cluster 3 > Cluster 1* Cluster 3 > Cluster 2*
	Cluster 2	113	2.70	4.19			
	Cluster 3	124	3.60	3.81			
	Total	299	2.92	5.10			
	Cluster	N	M	SD	F	p	Games-Howell
Divergent Thinking (10 items)	Cluster 1	62	2.07	6.18	267.43	0.000	Cluster 2 > Cluster 1* Cluster 3 > Cluster 1* Cluster 3 > Cluster 2*
	Cluster 2	113	2.37	4.08			
	Cluster 3	124	3.62	5.23			
	Total	299	2.93	8.44			
Motivation (7 items)	Cluster 1	62	2.10	5.23	103.93	0.000	Cluster 2 > Cluster 1* Cluster 3 > Cluster 1* Cluster 3 > Cluster 2*
	Cluster 2	113	2.52	3.68			
	Cluster 3	124	3.34	4.09			
	Total	299		5.48			

Note. * $p < 0.05$.

Students in the Medium Attribute (MA) group had higher levels of each attribute than those in the LA group but had lower levels in *Divergent Thinking, ConvergentThinking*, *Motivation*, *Environment*, and *Knowledge* than did those in the HA group.

Significant differences were found among the three clusters in their MCPSAT scores, F (2, 290) = 9.69, p = 0.00 (see Table 5). The HA students scored highest on the MCPSAT and the LA students scored the lowest. Post hoc Tukey tests indicated that the HA group significantly differed from the MA and LA students, while differences between the LA and MA groups were insignificant.

4. Discussion

This study aimed to investigate typology of different creative problem-solving groups. A newly devised instrument, the CPSAI, with five different subscales (*Divergent Thinking*;

Table 5: Mean and SD of MCPSAT and group differences between three clusters.

	Clusters	n	M	SD	F	p	Tukey
MCPSAT	LA	60	27.52	21.50	9.69	0.000	HA > MA* HA > LA*
	MA	110	28.61	17.01			
	HA	123	38	18.98			
	Total	293	29.26	32.33			

Note. * $p < 0.05$.

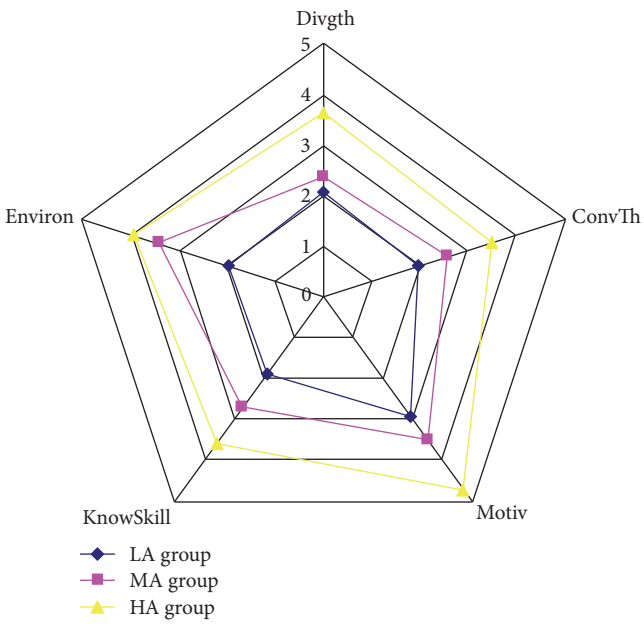

Figure 1: Creative problem-solving attribute combination patterns for HA, MA, and LA clusters.

Convergent Thinking; *Motivation*; *General Knowledge*; and *Environment*), was utilized in this study. Several analyses were computed to investigate the reliability and validity of the CPSAI, as well as its correlation with established instruments such as the MCPSAT, CAP, CTT-I, and IPI. Those instruments measure creative problem-solving in math, divergent thinking, convergent thinking, and family processes, respectively.

According to the results of the confirmatory factor analysis, most of the subscales yielded a reasonable fit, save for the *Convergent Thinking* scale. Further clarification may be needed for items measuring convergent thinking, such as rephrasing them in a way that allows examinees to understand them more readily. In addition, there have been studies indicating the importance of domain-specific knowledge in creativity [20, 23]. Therefore, the concept of domain specificity may need to be incorporated into the test questions for convergent thinking, motivation, and divergent thinking in the CPSAI in the future. As Brophy [34] pointed out, individuals constantly alternate between ideation and evaluation during the creative problem-solving process, such that these two types of cognitive thinking may work in a "zigzag pattern." This may have caused difficulty for the participating fifth and sixth graders in distinguishing between the divergent and convergent thinking processes. Divergent thinking and convergent thinking may not be processes that are exclusive of each other. While an individual explores alternatives, convergent thinking is also required to evaluate previous solutions or ideas and, based on the evaluation results, they will continue to or stop searching for new alternatives [34]. Future research may need to be conducted, with participants with higher levels of cognitive maturity.

Values for internal-consistency on each subscale ranged from .79 to .89, indicating good reliability. Further, the items interrelated well enough to be summed as a composite variable, and each of the five factors was measured well by its subscale items. The subscales statistically correlated with each other, ranging from .45 to .70, suggesting moderate to high relationships between them. The structures of the subscales shared some common ground yet were unique from each other, confirming Cropley's claim that these two types of cognitive processes (convergent and divergent thinking) are both used to generate ideas, but in different fashions [29]. Divergent Thinking and Convergent Thinking were the most highly correlated among the subscales. This corresponds to the results of the factor analysis, which revealed that these two concepts were not easily distinguished by the participants.

The results of the correlation analyses between the scores on the subscales and established instruments ranged between .20 and .60, signifying medium to large relationships, suggesting that there are similarities as well as differences between the subscales of the CPSAI and the other established instruments. For example, the Divergent Thinking scale had a significant but low correlation with TDT. This result can be explained by the domain specificity of creativity and divergent thinking. Baer theorized that creativity is domain-specific, such that creativity in one field cannot be transferred to another field, based on the low correlations among products in five tasks (telling stories; writing stories; writing poems; writing mathematical word problems; and making collages) [44–46]. In other words, an individual's creativity in drawing figures as tested in the TDT may not transfer to creativity in solving math problems.

The cluster analysis yielded three patterns of attributes, with the HA group having the highest mean scores across all of the attributes, followed by the MA group, and then the LA group. In addition, participants in the HA group

acquired the highest scores on the MCPSAT, followed by students in the MA and LA groups, respectively. Although the three groups significantly differed from each other across attributes, only the MCPSAT score of the HA group was significantly different from the other two groups; the MA and LA groups had similar scores on the MCPSAT. This implies that there might be a threshold effect required for attributes in creative problem-solving to have an impact. In other words, unless students have at least a threshold level (the midpoint of the 5-point scale) in all of the attributes, differences in these attributes below the threshold level do not result in a difference in actual creative problem-solving.

This empirical finding of the present study supports Cho's Dynamic System Model of Creative Problem-Solving Ability [23, 24, 30], in which all attributes of creative problem-solving are equally important and have to be adequately developed before superior creativity can manifest. More importantly, these results imply the importance of balanced development among attributes. No particular attribute stands out from the rest. Instead, attributes of creative problem-solving need to be developed equally to certain levels, as supported by Cho, who claimed that not only do attributes of creative problem-solving interact with each other to help solve problems in a creative manner during the process, but also creative problem-solving is an organic system that cannot develop properly without the balanced development of these attributes [24]. Therefore, two principles in the nurturing and development of creative problem-solving are as follows: (a) all attributes are equally important and (b) these attributes must all be developed to a certain level in order for an individual to perform creative problem-solving [47]. Moreover, past studies have discussed the threshold theory with regard to intelligence and creativity [48–50], but not the threshold theory's effect on other specific attributes. Therefore, these current findings should be further investigated to determine their generalizability.

5. Conclusion

In this evolving environment, creative problem-solving is essential for human beings to solve the complex challenges we face [3]. It is critical to equip our children with creative problem-solving abilities. This study investigated the typology of math creative problem-solving ability. Most importantly, the results of this study may have shown a threshold effect for creative problem-solving attributes, meaning that one has to achieve a certain level in divergent thinking, convergent thinking, motivation, environment, and knowledge and skills in order for them to have an impact on creative problem-solving ability. This study showed that the attributes in Cho's [23, 24, 30] model are equally important and need to be developed equally to certain levels, thus contributing to the existing knowledge regarding creative problem-solving.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding publishing this paper.

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Hindawi
Education Research International
Volume 2017, Article ID 3459631, 12 pages
https://doi.org/10.1155/2017/3459631

Research Article

Preparing Students for Global Citizenship: The Effects of a Dutch Undergraduate Honors Course

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Received 16 February 2017; Revised 12 June 2017; Accepted 2 July 2017; Published 27 August 2017

Academic Editor: Seokhee Cho

Using a mixed method approach, this case study investigates effects on the participating students ($N = 25$) of an undergraduate honors course in the Netherlands, aimed at global justice citizenship. Knowledge about effects of global citizenship courses is still limited. The Ethical Sensitivity Scale Questionnaire and the Global Citizenship Scale were used in a pre- and posttest design to measure possible development in the moral and civic domain among the participants of the course. In the qualitative part, deductive content analyses of students' work and students' written reflection on the course, utilizing the theory-based curriculum guidelines Global Justice Citizenship Education, were performed. In addition, a follow-up blog and interview were analyzed to learn students' perception on the effects of the course after half a year. Quantitative results show increased ethical sensitivity as well as global civic engagement and global competence among the participants. Qualitative results point in the same direction and provide deeper insights in the content of students' learning and the perceived impact of the course on their attitudes and behavior. Results are discussed in relation to theory on justice-oriented global citizenship and honors pedagogies.

1. Introduction

Preparing undergraduate honors students for their role as citizens of the world is an important task in higher education, given the challenges global society faces [1]. Furthermore, research indicates an above-average interest among honors students in moral issues and the wider world (see [2, 3] for a review). Nevertheless, global citizenship receives little attention in higher education and few studies consider the effects of global citizenship education on undergraduates [4]. It has been argued that such programs enable them to lead a responsible and moral life [5]. As discussed by Colby et al. [4], this effect has been demonstrated for service learning, which combines community service with academic learning and personal development. For example Lee et al. [2] found that gifted high-school students had an enhanced awareness of civic issues, increased motivation to engage in social issues in their communities, and new understanding and respect for diversity after a three-week service learning program.

In this study, we connect to the justice-oriented approach of global citizenship that includes a desire to improve society [6].

We conceptualize global citizenship similarly to Westheimer and Kahne's justice approach to global citizenship [7], which implies that "global citizens" take informed action based upon insights in structural causes of global injustice or sustainability issues. Next to this, our conceptualization of global citizenship includes a global approach to citizenship, as, in this globalized world, justice and sustainable issues unmistakably contain a global dimension. This global dimension is connected to Nussbaum's moral cosmopolitism [8, 9], especially regarding the abilities to think as citizen of the world and to imagine what it would be like to be in the position of someone quite different from yourself.

In the light of this conceptualization of global citizenship and based on literature about (global) justice-oriented citizenship education, curriculum guidelines were developed for the knowledge, moral, and social domain. A learning environment that combines elements from these

three domains acknowledges the needs of gifted students [10–12]. We call these curriculum guidelines Global Justice Citizenship Education (GJCE). For an overview, see Table 1. In short, these curriculum guidelines concern the following.

Knowledge Domain. In the knowledge domain, the guidelines are (1) gaining historical (root causes of injustice) insights. The historic dimension offers insight in the societal context in which the issue developed [7, 13, 14]. (2) Seeing local-global connections, as students should understand the global dimension of their own actions and the interdependence between places in the world [15]. (3) Focus on one global justice issue instead of gaining more superficial broader knowledge (see Davies et al. [14] on exploring issues) as narrowing the focus allows one to grasp the social, political, and economic structures that underlie injustice and power differences.

Moral Domain. In the moral domain, two curriculum guidelines were formulated. (1) Develop ethical and intercultural sensitivity [16–18]. Ethical sensitivity relates to the ability to take the perspective of "the other," to pay attention to the welfare of others, and to recognize ethical dilemmas [19]. When encountering people with other cultural backgrounds, students need intercultural sensitivity, the ability to notice and experience cultural difference [17, 18]. Ethical and intercultural sensitivity relate to one of the guiding aims in Nussbaum's' view on world citizenship: being able to understand the world "from the point of view of the other" ([8, p. 11], [20]). (2) Recognize (own) values and critically reflect on mainstream thinking [13]. The first is about recognizing values behind statements, ideas, and perspectives and evaluating how they relate to students' own values [13]. The second skill is critically reflecting on values, especially on "mainstream" thinking related to the dominant neoliberal ideology. This is important because neoliberal ideology highly impacts all aspects of education [21] and historically grown power differences lead to problematic assumptions in the western world about, for instance, "progress."

Social Domain. Regarding the social domain, the two guidelines are (1) contact people with different socioeconomic positions, cultural backgrounds, and life chances. Such contacts can yield new insight in oneself and one's biases [22] and (2) get to know positive role models: active and socially engaged people with both courage and persistence to contribute to a better world based upon other than mainstream values [4].

Experiential Learning in Civic Contexts. Finally, experiential learning in civic contexts was added to the guidelines. Colby et al. [4] emphasize the value of student centered learning and of pedagogies that actively and emotionally involve students in the learning process. In addition, when students can practice in civic contexts what we hope that they will learn, these authentic and intrinsically interesting tasks can be provided. Experiential learning in civic contexts can provide these possibilities.

Table 1: Curriculum guidelines Global Justice Citizenship Education.

Domains	Curriculum guidelines
Knowledge domain	(i) Gain historical (root causes of injustice) insights and see local-global connections (ii) Focus on one global-justice issue
Moral domain	(i) Develop ethical and intercultural sensitivity (ii) Recognize own values and critically reflect on mainstream thinking
Social domain	(i) Contact people with different socioeconomic positions, cultural backgrounds and life chances (ii) Get to know positive role models: active and socially engaged people
Experiential learning	(i) Spend at least 15 hours in civic contexts [33]

Based upon Schutte [34].

The current case study investigated the effects of an undergraduate honors course called "Society 2.0" in the Netherlands, which is aimed at global citizenship. The Dutch educational context is characterized by socially segregated schools [23] and low scores on civic skills and attitudes towards foreigners [24, 25]. Aims of citizenship education, such as active participation and social integration, relate to traditional national citizenship [26]. Furthermore, ethics are not explicitly treated. Under these circumstances, the youngsters' world could be broadened by contact with people from different socioeconomic and cultural backgrounds as well as by attention to their moral development.

Currently, honors programs are under development in Dutch higher education [27], which offers opportunities to develop new content and teaching methods, also on global citizenship.

In 2014, such an opportunity arose at the Hanze University of Applied Sciences, where two teachers, two students, and one researcher developed an undergraduate honors course "Society 2.0." The study load of the course is 112 hours, including eight class meetings of all together 16 hours (eight times two hours). The curriculum development team used the theory-based curriculum guidelines Global Justice Citizenship Education (see Table 1). The current study investigates the effects of the course as delivered in 2014 and 2015 on the participants of the two groups from both years.

Society 2.0 meets eight times for two hours (contact time), one evening every fortnight, and lasts four months. It focuses on alternative/social movements and their ideals (moral domain). The course starts with the values and norms of students' upbringing (moral domain) and then broadens out. Students delve into a societal theme (knowledge domain) and do a 15-hour internship at an alternative/social movement (experiential learning). While there, they interview people in that movement about their ideals (social domain, positive role models). In their lessons, the teachers cover different

perspectives and the importance of being nonjudgmental (moral domain). They mostly function as coaches but also teach some theory about ethics, conformism, and cultures (moral domain). Students acquire knowledge on societal (global) issues by writing two blogs on a self-chosen theme, exploring its historical-future and local-global dimensions (knowledge domain). Furthermore, one meeting is dedicated to a global issue: "poverty" in the first course and the "free-trade treaty TTIP" in the second (knowledge domain). Students back up their opinions and provide references in their blogs. In the final meeting, students present a "one-minute paper" on how they will contribute to a better world. They also make a product in small groups demonstrating how others could learn from their exposure to global citizenship.

Society 2.0' is geared to honors students, that is, students who are both willing and able to go beyond the regular program in terms of academic challenge and personal development [28–30]. They do not comprise a homogeneous group [31, 32]. Teaching honors students presumes that three conditions are met [28]: a safe learning community, academic challenge, and bounded freedom (facilitating autonomy and self-regulation). This pedagogical approach was applied to Society 2.0.

The researcher attended the course meetings in 2014 and 2015 and made the following observations. A "typical lesson" would start with an inventory of students' experiences during the past two weeks, for instance, their (search for) internship or homework on ethics. Teachers ask who wants to share his/her experience, and individual students respond, after which other students and teachers ask questions and/or add their own experiences. Some lessons begin with a short film on an alternative movement, followed by questions: what did you see, what do you think, why did they start this, and which values are involved? The teachers provide an overview of each lesson and its aims and ask how students are getting on with their assignments. Sometimes students spontaneously tell about an experience connected to the course. Each lesson has a general part for the whole class and a breakout part in which students work in small groups of three or four. In lesson three, which focuses on ethics, the teachers first present theory and then the students share their own experiences of unethical behavior within the group. This is followed by a homework assignment in which students had to be alert to ethical conduct of themselves and others over the coming week and condense these observations into keywords. Several students present their experiences with that assignment at the beginning of lesson four. Teachers include multiple perspectives in every lesson. Each meeting ends by looking ahead to upcoming lessons and discussing the homework assignments.

Two cohorts of students (2014-2015; 2015-2016), altogether 25 students, participated in the study. The main question asked in the present study is what do students learn from the undergraduate honors course aimed at global citizenship? That question has been broken down into three subquestions: (SQ1) Do students show an increase in ethical sensitivity and global citizenship (social responsibility, global competence, and global civic engagement) after taking the course?; (SQ2) How do students express themselves regarding knowledge and ethics when writing about a societal issue?; and (SQ3) Which insights do participants of the course report regarding knowledge, ethics, and their role as global citizens when reflecting on the course?

Table 2: Characteristics of the participants.

Participants (N = 25)	Descriptive traits
Age (mean)	19–25 years (21.24)
Female/male	Female 72%/Male 28%
Educational background students (number)	Economy (10) Law (5) Sports (4) Education & technical/computing (2) Nursing & communication (1)
Year of study (number)	Second year (4); third year (16); fourth year (5)
Educational background parents/caregivers	56% completed higher education
Perceived cultural-ethnic background (number)	Dutch (24); Dutch-Moroccan (1)

2. Methods

2.1. Participants. The 25 students in this case study all participate in an honors talent program at their own institute/school, meaning that they follow a 30-ECTS two-year extracurricular program. ECTS refers to European Credit Transfer System. One point corresponds to 24 to 30 working hours for the average student. For an overview of the participants' characteristics, see Table 2. Regarding parental educational background, the percentage of having completed higher education is comparable with the overall student population of the Hanze University of Applied Sciences. It is above the average educational level in the Netherlands, as about 34% of the Dutch population completed higher education [35].

During the course, participants had to choose a societal topic. Twelve students (46%) chose to write about a sustainability-related issue. Nine (35%) chose an issue related to equality: either social/cultural, such as discrimination and social acceptance, or financial, such as equity-based crowd funding and unconditional basic income.

Participants further had to choose an organization to do a short internship. Fourteen students (54%) chose an internship related to the issue they had written about. For instance S3, a business student, wrote blogs about self-sufficient living and did her internship at "Place the World," a place to work and share ideas on living with nature in a multicultural world. S14, studying human resource management, wrote blogs about discrimination and did her internship at the discrimination contact point. In other instances, the issue covered in the blog was not related to the internship: for example, S4, doing sports studies, wrote blogs about green playgrounds but did her internship at the discrimination

contact point. S10, studying life science, wrote blogs about "art from waste" but did her internship at Young Gold, a project to promote volunteer work among youngsters. For three students the internship is unknown.

2.2. Data Collection

2.2.1. Instruments. For the quantitative measure to answer the first question, two instruments were used. The Ethical Sensitivity Scale Questionnaire (ESSQ) consists of seven dimensions and 28 items, which are measured on a 5-point Likert scale [36, 37]. There is some hierarchy in the dimensions, from basic to more complicated [38]. The operationalization of the Ethical Sensitivity model is satisfactory in that the psychometric properties of ESSQ are scientifically valid [36, 37, 39]. Reliability analysis of the subscales [40] yielded scores between $\alpha = .78$ and $\alpha = .50$. Reliabilities tend to be low due to the multidimensional construct as well as the high abstraction level of the concepts [36]. Two examples of the dimensions are "caring by connecting to others" (with the item "I tolerate different ethical views in my surroundings") and "working with interpersonal and group differences" (with the item "I try to consider another person's position when I face a conflict situation").

The Global Citizenship Scale (GCS) [41, 42] aims to measure global citizenship as an outcome of global education. GCS was used in this study because its three dimensions relate to the intended learning goals set forth in our curriculum guidelines GJCE. These dimensions are "social responsibility" (including social justice), "global competence" (including global knowledge and intercultural communication), and "global civic engagement" (including involvement in civic organizations and global civic activism). GCS was validated by means of two confirmatory factor analyses with multiple datasets [41], resulting in a measurement model of six first-order factors (self-awareness, intercultural communication, global knowledge, involvement in civic organizations, political voice, and global civic activism), three second-order factors (social responsibility, global competence, and global civic engagement), and one higher-order factor (global citizenship). These results support its underlying theoretical model. Reliability analysis of the subscales [40] yielded scores from $\alpha = .69$ to $\alpha = .92$. The items of the GCS are measured on a 5-point Likert scale. For example, one item in the dimension "social responsibility" is "the world is generally a fair place." In the dimension "global competence", one item is "I am confident that I can thrive in any culture or country." Finally, in the dimension "global civic engagement", an item is "over the next 6 months, I plan to get involved in a program that addresses the global environmental crisis".

2.2.2. Data. To answer SQ1, a pre- and posttest design was used to measure the effect of the course on students' ethical sensitivity and global civic competence, engagement, and responsibility. Students filled out the questionnaires ESSQ [36, 37] and GCS [41, 42] in class at the beginning of the first course meeting (pretest) and at the end of the last course meeting (posttest). After being provided with an explanation about the research and the anonymously processing of the data, all the students agreed to participate.

To answer SQ2, how do students express themselves regarding knowledge and ethics when writing about a societal issue?, data were collected from two blogs that students had to write as part of their course assignments. For blog 2, they were asked to "explore a theme/issue that appeals to you and discuss a book, article, or presentation of your choice." For blog 3, they were asked to "locate your theme in a historic-future and local-global perspective." The collected data comprise 32,081 words ($N = 24$).

To answer SQ3, which insights do participants of the course report regarding knowledge, ethics, and their role as global citizens when reflecting on the course?, data were collected from their final blog on "reflection and evaluation" and from their answers to evaluation questions. These two questions are open-ended: (1) what is the most important thing that you learned about society? Please explain why this is important to you and (2) what possibilities do you see for yourself to contribute to a more just society in the future? The collected data comprise 12,595 words ($N = 25$). Again, the focus was on ethics and knowledge and on global citizenship: what do students write about their role as global citizens?

Finally, we investigated the students' perception on possible effects of the course half a year after they finished it. That time frame was selected because effects, especially in moral development, might fade away or appear after a course has ended [4]. Therefore all participants of the two courses were approached three times by email. In addition, participants of the second course were approached once through the Facebook group. In the end, data were collected from nine students. These nine were then invited for an interview, which started with the request to write (again) a blog giving their "reflection on the course" in about 15 minutes. After that, they were asked two questions: (1) what is the most important knowledge (emphasis) you gained from the course? and (2) what is the added value of the course in your daily life, how do you notice this, and how do other people notice this? Two of the interviews were conducted using Skype. The categories for each subquestion are shown in Table 3.

2.3. Data Analysis

2.3.1. Quantitative Analyses. The impact of the course on students' *ethical sensitivity* and *global citizenship competence, social responsibility, and global civic engagement* was tested by using the nonparametric Wilcoxon Signed Rank Test for repeated measures. A nonparametric test was chosen because of the small dataset in this study ($N = 25$).

2.3.2. Qualitative Analyses. First, two coders read and summarized all five blogs as to gain a gain a good understanding of the data. This wider frame helped to put outcomes of the actual analysis into perspective. After this, the blogs of interest for the current study (blogs 2, 3, and 5) were coded deductively using the following codebook. Regarding the category ethics, the code "ethical sensitivity", that is, writing about ethical aspects of a situation, was used. The

Table 3: Data collection and qualitative data analysis subquestions 2 and 3.

Subquestion	Data	Categories
2	Blogs 2 and 3 ($N = 24$)	Knowledge and ethics
3	Final blog + two open-ended evaluation questions ($N = 25$)	Insights (knowledge, ethics, global citizenship) and intentions (role global citizen)
	Follow-up blog + interview ($n = 9$)	Insights (knowledge, ethics) and behavior (global citizen)

Table 4: Overview of codes for each category SQ2.

Category	Code
Knowledge	(i) Historical (-future) dimension (ii) Local-global connection
Ethics	(i) Ethical sensitivity (both own behavior and that of others/groups)

Table 5: Overview of codes for each category SQ3.

Category	Code
Intentions (future) role as global citizen	(i) Sustainability-related (ii) Social area
Insights	(i) Knowledge-related (ii) Ethics-related (iii) Global justice citizenship (other)

dimensions from Narvaez's theory [38] on ethical sensitivity, which correspond with the ESSQ [36, 37], were all categorized as "ethics." In addition to elements of caring ethics from this theory, also more "justice-oriented" fragments were coded "ethics." Furthermore, fragments were categorized under "ethics" not only when students wrote about their own attitude and behavior but also when they wrote about behavior and attitudes of others/groups in society. Regarding the category knowledge, the codes "historical dimension" and "local-global connections" were deduced from the curriculum guidelines GJCE. Furthermore, the code "global justice citizenship (other)" was used, which relates to the curriculum guideline "critically reflecting on (mainstream) values." Finally, regarding the impact of the course, the code "students" intentions regarding their role as global citizens' was added. Table 4 shows the categories and codes for SQ2 and Table 5 presents the categories and codes for SQ3.

Two coders independently coded all materials used in this qualitative part of our study. Coding was done by selecting the relevant parts of the blog-texts and by adding the code in the text margins. After the two different documents were combined into one and codes were compared as to establish interrater reliability, the coders discussed differences until agreement was reached. Then, in the next step, fragments falling within one category were put together. Finally representative examples were selected by the first and second author.

3. Results

3.1. Quantitative Results. A Wilcoxon Signed Rank Test revealed a statistically significant increase in ethical sensitivity after participating in Society 2.0 on three of the seven subscales. Regarding ESSQ 2: Taking the perspectives of others, $z = -2.131$, $p < .033$ with a medium effect size ($r = .30$) using Cohen [43] criteria of .1 = small effect, .3 = medium effect, and .5 = large effect. The median score on "taking perspectives of others" increased from (Md = 3.88) before the course to (Md = 4.25) after the course. Regarding ESSQ 3: Caring by connecting to others, $z = -2.179$, $p < .029$ with a medium effect size ($r = .31$). The median scores on "caring by connecting to others" were the same on both occasions (Md = 4.00). And regarding ESSQ 5: Preventing social bias, $z = -2.695$, $p < .007$ with a medium effect size ($r = .38$). The median score on "preventing social bias" increased from (Md = 3.50) to (Md = 3.75) after taking the course. See Table 6 for details on these results.

Regarding global citizenship as measured by the GCS, a Wilcoxon Signed Rank Test revealed a significant increase across all three subdimensions of global civic engagement and in two of the three subdimensions of global competence, namely, self-awareness and global knowledge. The results are as follows. Self-awareness: $z = -4.00$, $p < .0005$ with a large effect size ($r = .57$). The median score on "self-awareness" increased from (Md = 2.67) at the outset to (Md = 3.67) after taking the course. Global knowledge: $z = -3.02$, $p < .003$ with a medium to large effect size ($r = .43$). The median score on "global knowledge" increased from (Md = 3.33) to (Md = 3.67). Involvement in civic organizations: $z = -2.79$, $p < .005$ with a medium to large effect size ($r = .40$). The median score on "involvement in civic organizations" increased from (*Md* = 2.75) to (Md = 3.25). Political voice: $z = -2.53$, $p < .011$ with a medium size ($r = .36$). The median score on "political voice" increased from (Md = 2.25) to (Md = 2.75). Global civic activism: $z = -2.93$, $p < .003$ with a medium to large effect size ($r = .40$). The median score on "global civic activism" increased from (Md = 3.00) to (Md = 3.33) after taking the course. See Table 7 for further details.

To summarize the results from the quantitative part of our research on the effect of participation in Society 2.0, it was found that students showed an increased score on three of the seven dimensions of ethical sensitivity (with medium effect sizes). Further, students' scores had also increased on two of the three dimensions and within those on five of the six subdimensions of global citizenship (with medium to high effect sizes).

Table 6: Pre- and posttest differences on ethical sensitivity (ESSQ). $N = 25$.

ESSQ	Md (pre)	Md (post)	Z (p)	r
(1) Reading and expressing emotions	4.00	4.00	−.84 (.400)	.12
(2) Taking the perspectives of others	3.88	4.25	−2.13 (.033)	.30
(3) Caring by connecting to others	4.00	4.00	−2.18 (.029)	.31
(4) Working with interpersonal and group differences	3.75	3.75	−1.77 (.077)	.25
(5) Preventing social bias	3.50	3.75	−2.695 (.007)	.38
(6) Generating interpretations and options	3.67	4.00	−1.61 (.107)	.23
(7) Identifying the consequences of actions and options	3.50	3.75	−1.88 (.060)	.27

Table 7: Pre- and posttest differences on the Global Citizenship Scale (GCS), $N = 25$.

Dimension	Subdimension	(Md) pre	(Md) post	Z (p)	r
Social responsibility		4.00	4.00	−.23 (.818)	.03
Global competence	Self-awareness	2.67	3.67	−4.00 (.000)	.57
	Intercultural communication	4.00	3.67	−.36 (.720)	.05
	Global knowledge	3.33	3.67	−3.02 (.003)	.43
Global civic engagement	Involvement in civic organizations	2.75	3.25	−2.79 (.005)	.40
	Political voice	2.25	2.75	−2.53 (.011)	.36
	Global civic activism	3.00	3.33	−2.93 (.003)	.40

3.2. Qualitative Results. SQ2: How do students express themselves regarding knowledge and ethics when writing about a societal issue? Content analysis of the blogs that students wrote about a self-chosen societal issue revealed the following points. Sixteen students (67%) wrote about *knowledge* in the way we defined it (historical-future and local-global connection). Fourteen out of 24 (58%) treated the *historical dimension* in one way or another, mostly in a few (four to nine) sentences. Five students described the historical dimension from the angle of an alternative movement rather than of a societal/global issue. For instance: (S15) *The strange thing about self-sufficient living is that it is not a new lifestyle at all, because in earlier days we all had to organize and arrange our own food and ways to keep warm.* [...] *nowadays we forget how it will be to take care of your own food and heating.* A second example is the following: (S8) *Permaculture was invented in 1970 by two Australians, Bill Mollison and David Holmgren from the university of Tasmania. Together they did research on the functioning of the ecosystem in the Tasmanian forests. The research was motivated by agricultural issues that were going on. The aim was to formulate principles to enable man to build and maintain an ecosystem with optimal attention for nature.*

An example touching upon the historical dimension of discrimination is the following blog. (S14) drew connections with what she learned at her previous school about not being allowed to discriminate. The examples she used were World War II, racial segregation in the USA, and "apartheid" in South Africa. She tried to find out if it is possible to see a turning point in the way people (in a certain country) think about discrimination. She wrote that she came to realize the answer to this question can be different depending on the country and the ethnic group involved.

Regarding the *local-global* perspective, it was found that 11 students (46%) dealt with that topic in one way or another. Two of them wrote about an issue that is often not perceived to play a role in the Netherlands, just in other parts of the world. (S25) wrote about poaching: *I always thought that animals living in the nature in the Netherlands had a rather good life here, but that is not true at all: 3663 poaching alerts within one year.* The other student (S20) argued that *the impact of internet censorship is not as dependent on location as people seem to think and not limited to countries like China and North Korea. In the Netherlands there is trust in the government and the legislation. However, from the examples* [this student gave] *it is clear that in democratic politics also a lot of "people-unfriendly" decisions are being made.*

Other students also wrote on this aspect. For instance, one (S7) described the international framework of human rights, such as the universal declaration of human rights and the EU legislation. Another (S18) mentioned the global scope of the effects of the use and depletion of fossil fuels. Yet another (S2) compared the attitude of Dutch people on homosexuality with that of people in several other countries.

When coding the blogs, we noticed that students had learned both from reading each other's blogs and in interaction with each other. Students responded to each other's blogs, writing that an issue was new for them and that they were interested in it. Furthermore, they asked follow-up questions. For instance (S13): *Nice blog! I also think it is a very interesting issue* (barter economy). *Are you familiar with the trend that people even exchange food that they have left over;* such follow-up was often about the other student's experiences and opinions. Several also delivered new input on the issue. For instance, *Your blog reminded me of my own "doubts" about what to do in life to and how to become more*

Table 8: Overview of codes assigned for each category SQ2, $N = 24$.

Category	Code	Number of students	Number of fragments
Knowledge/insights	(i) Historical (future) dimension	14	22
	(ii) Local-global connection	11	11
Ethics	(i) Ethical sensitivity (both own behavior and that of others/groups)	14	30

happy. [...] *I also immediately thought of a book I am reading* [...]. For an overview of the assigned codes for knowledge and ethics, see Table 8.

Fourteen students (58%) described *ethical* aspects and/or ethical considerations, either in their own blogs or in response to those of others. In total 30 separate fragments were coded "ethical sensitivity." Most writings concern ethical aspects of the theme/social issue students had written about. Four students wrote about unethical behavior in society in the form of discrimination. One (S14) provided a detailed analysis of the process of discrimination. After that she showed sensitivity to social bias, writing *When being white in the Netherlands wanting to avoid racism, one easily makes the mistake to become defensive and forget that you were influenced by the system you grew up in*. The writers go on to relate this knowledge to his/her own thoughts and behaviors. Another student (S26) also noticed the prevalence of discrimination and subsequently wrote, *Fighting discrimination starts with yourself*.

Four more students focused on social inequality and ways to overcome it. For instance, regarding unconditional basic income (S5), *A man had to apply for jobs because he was obliged to find a job as soon as possible, whilst being out of work meant he could take care of his ill mother, who otherwise would have to go to a nursing home*. Another student (S13) showed involvement with the welfare of others by writing *I believe this initiative* [store for homeless people] *is great. Homeless people getting the opportunity to pick out free clothing*.

Two other students wrote about the unethical behavior of states and banks. One (S20) described how unlawful behavior of intelligence agencies has consequences for people's privacy. In a similar vein, (S19) detected a risk for low-educated people to become victims of nearly bankrupt enterprises. In response to that blog, another student (S12) proposed possible solutions to this problem, namely, establishing a "watchdog" and providing information.

Finally four students wrote about ethical aspects of sustainable food issues. As one wrote *With the same reasons (money, lust) people kill animals. Why they do it, I can't understand*.

Although the fragments on ethics were not coded separately on the different dimensions of ethical sensitivity, we noticed that the fragments mainly reflect the following dimensions: involvement with welfare of others (ES3); seeing own prejudices, social bias regarding ethical issues (ES5); looking for alternative solutions for ethical problems (ES6); and seeing consequences of actions and options (ES7).

SQ3: Which learning outcomes do participants of the course report regarding global citizenship, ethics, and knowledge when reflecting on the course? When writing about *intentions* regarding *their role as global citizen*, *sustainability* came up 12 times (48%). Seven students did formulate intentions regarding their own sustainable behavior: eat no meat or less meat; use less packaging; reuse things; buy second-hand clothes; exchange and share; make use of local gardens; eat vegetables in season and biological food; and do not unnecessarily turn on the lights. Three students formulated other intentions regarding sustainability. For instance, (S4) wrote *Now that the course has ended I want to further delve into this subject (green playgrounds) and hope to start this project in several towns.* (S3) wrote, *I intend to help spread the message about sustainable living for man, plants and animals.* And (S15) wrote *Finally I found something concrete in my own discipline (civil engineering): building with nature.* One student (S15) wrote *The most valuable* [lesson] *I learned from my internship (and the course) is the knowing that you are not alone. You never are the only one who worries (in my case about the climate) about the world. Speak out your "worries" and especially what you are interested in. When people hear that you are interested in something, they might (unconsciously) look for information and soon something might come up for you.*

Twelve students (48%) formulated intentions *in the social area*. Four of them intend to do or continue volunteer work (S6, S10, S15, and S20). For instance (S15) wrote *One year ago I stopped with volunteer work, which I did since I was 16 years old. During the course I noticed how much I miss that, so I will immediately look for that again.* Another student was looking specifically into how he can contribute to the town he is living in (S8). Two more students had already started with volunteer work (S26, S18). The intentions of the last four were related to equality, justice, and ethics. (S16) wrote *Bring several cultures together by means of organizing a festival on short notice focusing on the multicultural society. The idea is that bands from [town] and from the asylum seekers center perform together, and the aim to connect people* [this has been accomplished during the course]. (S9): *I study law and that is where I see myself contribute to a more just society in the future.* (S22): *Inform and activate other people and make them aware of ethical issues.* Finally, two students emphasized the importance of taking small steps at a time. For instance (S14) wrote *I came to realize that I have to focus on specific issues and take one step at a time*.

Regarding *insights* gained from the course, 19 students (76%) mentioned *ethical aspects* in altogether 38 fragments. Fourteen students mentioned that they are more aware of or have more respect for people who are different from themselves. Their comments reflect two dimensions of ethical sensitivity: exploring multiple perspectives (ES2) and understanding that differences could lead to misunderstandings (ES4). For instance (S22) wrote *Respect each other's identity, try not to judge and pay respect*. And (S25) wrote *last year*

Table 9: Overview of codes assigned for each category SQ3, $N = 25$.

Category	Code	Number of students	Number of fragments
Intentions (future) role as global citizen	(i) Sustainability-related	12	16
	(ii) Social area	12	13
	(iii) Other	4	4
Insights	(i) Knowledge-related	18	27
	(ii) Ethics-related	19	38
	(iii) Global justice citizenship (other)	5	5

was a period in which my world became much broader and I developed more respect for "things" which are different. (S4) wrote *After my internship I came to realize that I also have prejudices about other people and other cultures.* (S5) wrote [...] *We talked a lot about homeless people and also about people who live in poverty, and who, according to us, sometimes make stupid choices (you don't smoke if you do not have money, do you). We can in no way judge about this, without knowing more about people, situations and surroundings. So sometimes it is good to not take your own view and prejudices too seriously and important to be a little more forward looking.* And (S16): [...] *I was opposed to refugees, but thanks to the course and especially insights from others, my thoughts about this have been changed.*

Two students wrote that all alternative movements deserve respect. Also two students mentioned that they have become more aware of ethics, norms, and values. For instance (S23): *I more often remark on ethical aspects and talk with others about that. I also notice that I more often watch interesting documentaries about this subject.* One student (S25) wrote that the most important lesson she learned about society concerned *The helping of each other. People are there for you and that is a reassuring feeling.* Also one student wrote that he is more aware of other people (S8): *I cycle through the city more happily and notice more the people around me. I more often talk with them and in that way come to know things. This interest for people from Groningen has been aroused by the course "Society 2.0."* Finally, one student (S9) wrote *Society only functions if we keep talking to each other. Ignorance creates a distinction between groups within society.*

Eighteen students (72%) reported *knowledge-related insights* in altogether 27 text fragments. Almost all of these refer to gaining broader knowledge and a broader view. For instance (S13) wrote *I became fascinated by the barter economy.* (S17): *An inspiring group of motivated students have also pointed out all kinds of movements to make this world an even better place.* (S23): *I learned a lot about society, about different cultures, alternative movements and ethical aspects. Very important aspects which are not always being discussed in daily life.* (S24): *I am much more aware of what is going on in the world and I notice more articles about a societal theme like TTIP, which I then read with pleasure.*

Other insights, specifically regarding *global justice citizenship*, were reported by five students (20%). Two students wrote about equality. For instance (S10) wrote *I learned it is good to help a little in society, but that help is not always necessary whilst "we people from western countries" feel the urge to help people living in a less prosperous countries then we do "the white savior syndrome".* Two students wrote about the importance of collective action/cooperation for a better world. For instance (S6) wrote *When I look at the Netherlands I can see that we have become more individualistic. We have to collaborate to make the world a better place. We expect too soon that other people will change and that it is no use to do something on your own. Although you will have to collaborate, you can also contribute on your own.* As one student (S19) remarked when asked to describe the most important lesson (s)he had learned from Society 2.0, it was *that most people think too mainstream.* For an overview of assigned codes regarding students' intentions as global citizen and gained insights, see Table 9.

When coding the students' final blogs, we also noticed that students often said they learned from their internship. Seventeen of the 25 students mentioned the internship in altogether 45 fragments.

With regard to the students' perception on effects on them ($n = 9$) *half a year after the course was finished*, the following points were found. Students wrote in their follow-up blogs about how the course still influenced them. Three of them mentioned paying more attention to their surroundings. For instance (S1) mentioned *seeing more what happens around me*; and (S3) recalled *noticing more small initiatives when walking in the street*. Others reported that they developed a different view or perspective. (S17): *developed critical look regarding certain issues, for instance TTIP.* (S19) reported *notice that I look from a different perspective, which sometimes leads to nice insights in the tough financial world.* And related to ethics, (S1) is *looking for alternative solutions for problems, also involving fairness*.

When asked about specific *knowledge* gained from the course, all but one student said things like "not particularly knowledge." (S8): *thoughts and ideas that you share with others and that help broaden your horizon*. (S3): *that you have to start with yourself, but after that it is also important to share your ideas or initiatives*. (S1): *alternative movements, what you can reach with those, however small they may be.* And (S14): *I better think about my own opinion, have become more critical*. One student did mention gaining specific knowledge, but not on a global issue. (S7): *what I really remember is conformism, I knew the concept but never gave it much thought. How she [the teacher] told about it, I thought yes, everybody does it, it just happens.*

When asked for the *added value in their daily lives*, three students mentioned the dialogue with others, for instance

(S8): I *share more thoughts and ideas with people and take initiatives to do things together (with colleagues)*. (S14): [...] *more open to opinions of others and take things not personally anymore*. Another student brought up the attitude towards others (S7): *Try to be positive and gay every day and give compliments and also become happy from the reactions I get*.

Two more students mentioned ethics-related aspects. (S1): *pay more attention to someone else's norms and values*. (S5): *my acting has changed a lot, for instance regarding homeless people, "you have a lot less than I have while I can easily do with a little less money"*.

Four students mentioned sustainable behavior: (S5): *change of lifestyle, more fresh and biological food*; (S1): *more thrifty with waste*; (S17): *eat less meat and more aware of power consumption*; and (S7): *don't let the water run, removing the electric plug, don't leave the lights on and so on*. One student mentioned now being able to acquire deeper knowledge (S5): *more deepening when reading a magazine on global justice issues*.

4. Discussion and Limitations

In our research on the effects of a global citizenship course on the participants, quantitative results showed a positive impact on students' ethical sensitivity as well as on their attitude and behavior as global citizen. The analysis of both students' work and their perception on what they learned points in the same direction. The course offered them new insights and broader knowledge, made them think about ethical issues and their values, and stimulated them to deal with their role as global citizen.

To answer the first subquestion SQ1: do students show an increase in ethical sensitivity and global citizenship (social responsibility, global competence, and global civic engagement) after taking the course?, a quantitative measure of ethical sensitivity ESSQ and the global citizenship GCS in a pre- and posttest design were used. Results revealed increased ethical sensitivity on three of the seven dimensions of the ESSQ: "taking the perspective of others" (which relates to exploring multiple perspectives on situations and events); "caring by connecting to others" (which relates to the process of expanding one's sense of self to include others and involves developing a sense of connectedness to other people, both globally and locally); and "preventing social bias" (which involves understanding, identifying, and actively countering bias). Effect sizes were medium. No significant increase in scores was found on four dimensions: "reading and expressing emotions," "working with interpersonal and group differences," "generating interpretations and options," and "identifying the consequences of options and actions."

Results regarding global citizenship revealed an increased score on the dimensions "global civic engagement" and "global competence." Effect sizes were medium to high. Global civic engagement relates to involvement in civic organizations, political voice, and global civic activism. Regarding global competence, an increased score was found on "self-awareness" (recognizing own limitations and ability to engage successfully in an intercultural encounter) and "global knowledge" (displaying interest and knowledge about world issues and events) but not on intercultural communication. Students' scores did not significantly increase on the third dimension, namely "social responsibility" (awareness of interdependence and social concern for the environment, other people, and society in general). This result might be related to the rather high score on both intercultural communication and social responsibility that the students already had recorded at the start of the course (Md = 4 on a 5-point Likert scale).

Based on these results it can be concluded that students increased their ethical sensitivity as well as their global competence and global civic engagement by taking the course. However, the absence of a control group means that the results should be interpreted with some caution, as it cannot be proven that it was solely the course that caused this increase. Furthermore, the sample size of 25 students is rather small and should be considered a major limitation with regard to the quantitative analyses with the instruments ESSQ and GCS.

Regarding our second subquestion (SQ2), how do students express themselves in the knowledge and ethics when writing about a societal issue?, content analyses of two blogs revealed that students dealt in some way with *ethical aspects* and *knowledge* when writing about a self-chosen societal issue. For instance, they wrote about the ethical aspects of discrimination, unconditional basic income, behavior of states and banks, and sustainability. With regard to *knowledge* most of the writings about historical aspects were found to be short. Notably, the students had learned about each other's issue and in that way broadened their knowledge about societal/global issues. Students regularly expressed enthusiasm about new insights, although it cannot be proven that what they wrote in their blogs is a reflection of new knowledge acquired in the course.

Regarding our third subquestion (SQ3), which insights do participants of the course report regarding *ethics, knowledge and their (future) role as global citizen* when reflecting on the course?, students reported *knowledge*-related insights, mostly referring to broader knowledge and a broader view. Likewise, students reported *ethics*-related insights, especially having more respect for people different from themselves. Signs of insight into other aspects of justice-oriented *global citizenship* were also visible, namely, regarding equality, individualism, and mainstream thinking. It was further noted that students wrote about the importance of their internship. Students' *intentions about their (future) role as global citizen* were equally related to sustainability and to the social arena, such as volunteering, bringing cultures together or striving for more justice within their profession. Although the giving of politically correct answers cannot entirely be excluded, we think that there are several circumstances in this course that might make the probability of this kind of answering smaller. First: in this course there is not something like right or wrong according students' intentions for the future. Instead students reflected on their intentions and plans during the course and had to give arguments for choices. Second: in that same vein, there were students who did not have concrete plans yet, but nevertheless passed the course. Third: several of the intentions of students were already put to practice and

students wrote and told about what they learned from it; hence this did reflect their behavior and not a tendency to come across as, for example, ethical. Fourth: in their blogs and during classes (observed by the first author), students showed severe enthusiasm about new insights and new experiences they got and intentions were linked to these insights and experiences, for instance, becoming vegetarian, organizing a cultural festival with refugees and inhabitants of a village, and making more active contact with unknown others.

Finally, from the follow-up blog and interview among nine students half a year after participating in the course, it can be concluded that students experienced that Society 2.0 still had an influence on them. This was especially apparent in their writing and talking about taking a different perspective and paying more attention to (people in) their surroundings. Students mentioned that they gained more insights than specific knowledge, giving the importance of sharing ideas as an example. Regarding behavior, five students mentioned that their attitude towards others had changed (towards sharing ideas, paying more attention) and four students remarked that they were behaving more sustainably.

It should be noted that not all students were interviewed; only nine participated in the follow-up blog and interview. It might be that the students who agreed to participate in an evaluation six months after taking the course are not representative for the whole group. However, the fact that no more students signed up for the follow-up study, even though their involvement with the course seemed to be deep, could be related to the extra workload of 15 ECTS each year in an honors program and to the half-year internship in the third year of study, conditions that applied to 64% of the students in this course.

The reason why this course had a positive impact on the participating students could be related to the use of the theory-based insights underlying the development of the course as well as to the teaching behavior. Regarding the theory, the curriculum guidelines GJCE in the knowledge, moral and social domains combined with experiential learning, were largely implemented in the course. Several ways of gaining more knowledge on societal/global issues were combined with explicit attention for ethics and an internship at an alternative social movement. The latter activity offered new perspectives on mainstream values and positive role models for the students.

Theoretical insights regarding honors pedagogies were also implemented and might have contributed to the results of the course as well. These were offering a safe learning community, academic challenge, and bounded freedom [28]. Of special note is that a great deal of freedom was offered. Students could choose an issue to write about, an internship, and the form and content of their final assignment. Community-building was accomplished in two ways: the course was started with attention for the values and norms the students were brought up with; and the teachers offered space for the students to exchange experiences related to the course. Students wrote they had learned from each other. Teachers also paid attention to different perspectives and emphasized being nonjudgmental, which is reflected in the students' writing and perceptions of what they learned.

Despite the positive outcomes of the course, students seem to have merely broadened their knowledge and hardly gained insight into the root causes of injustice, which is one of the curriculum guidelines GJCE. To achieve the latter aim, a more extended course will probably be necessary. Moreover, specific attention would have to be given to the structures that maintain injustice for the students to develop such insights.

Also, it should be kept in mind that the participants in this case study were honors students. The results might be different for regular (i.e., nonhonors) students. One reason for this is that high ability students on average reveal more interest in ethical issues [36, 44]. Finally, students deliberately chose to participate in this course aimed at global citizenship. Making that choice implies that they were already motivated to find answers about their role as citizen or were at least curious about the subject of global citizenship. The results might be different when such a course is mandatory. However, three principles that teachers applied in the course "Society 2.0" could also contribute to positive results in other contexts: starting with the student (in this case relating their background to their values and opinions); responding to differences between students; and making of adaptions in the course program when it seems necessary for the students' learning.

5. Conclusions

Under current conditions of emerging populism and severe ecological problems worldwide, undergraduate students should be able to count on our help and support in their efforts to gain deeper insights in the global society and to find their own way to act as an engaged global citizen. Honors students especially, with their above-average motivation, abilities, and interest in moral issues, could also contribute to solutions of global justice and sustainability issues. The results of our case study show that a 112-hour theory-based global citizenship course can have a positive impact on undergraduate honors students' insights, ethical sensitivity, and the development of attitudes and behaviors as engaged citizens.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgments

The authors like to thank the Hanze Honours College, Loes Damhof, Anique Elling, Nelleke de Jong, Arie Kool, Jacqueline Selker, and Richard Wiltjer for their positive and indispensable contribution to this study.

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Hindawi
Education Research International
Volume 2017, Article ID 4162957, 8 pages
https://doi.org/10.1155/2017/4162957

Research Article

How Do School Children and Adolescents Perceive the Nature of Talent Development? A Case Study from Finland

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Received 24 February 2017; Revised 18 June 2017; Accepted 4 July 2017; Published 7 August 2017

Academic Editor: Lieven Verschaffel

This article examines how school children and adolescents ($N = 607$) perceive the nature of talent development. More particularly it is investigated whether students perceive intelligence and giftedness as developing or as inherent and how students' perspectives on talent development are related to their learning outcomes. Participants were students in elementary ($n = 200$), lower secondary ($n = 256$), and upper secondary school ($n = 151$). The results showed that students perceived the nature of intelligence as more malleable than giftedness. Along with this domain-specific variance, there were also age and gender related differences in students' perceptions. By examining the relation between implicit beliefs and students' academic achievements, it was found that growth-oriented views about intelligence, but fixed ideas about giftedness, indicated higher math grades. The results suggest that the relationship between implicit beliefs and academic outcomes might not be as straightforward as previous studies have suggested.

1. Introduction

Education for 21st-century skills has inspired researchers from different fields of science to propose competencies and approaches that promote creativity and talent development [1]. The holistic approach to school pedagogy includes educating for a growth mindset in learning that allows challenges and creative ideas to flourish in the classroom. Educating for a growth mindset can be seen as one of the most important pedagogical approaches for learning. A growth mindset also encourages gifted students to try harder instead of simply trusting their current abilities [2]. In this article, our aim is to explore how school children and adolescents perceive the nature of talent development. Our special interest is in the mindsets of these students with respect to intelligence and giftedness and whether they see them as developing or inherent.

Laypeople have their own beliefs about intelligence and giftedness (cf. [3, 4]). These implicit theories, existing in the minds of individuals, are private and informal [4, 5]. Implicit theories are important, because they are influential in real-life situations, even more so than explicit theories, that is, research based theories and definitions developed by scholars [3]. One relevant concept that concentrates on implicit theories is Dweck's [6] theory of implicit beliefs about the nature of intelligence or other basic qualities and is based on the idea that people can have a fixed mindset (entity theory) or a growth mindset (incremental theory). Those who have a growth mindset believe that intelligence, personality, and abilities can be developed. Those with a fixed mindset believe that these basic qualities are static and unalterable.

Yet why do mindsets matter? The importance of studying students' mindsets about intelligence has been explained by the impact mindsets have been shown to have on school achievement, future orientation, and educational choices [6]. Research has shown that students' mindsets about intelligence play a vital role in their learning success and in confronting educational challenges. According to Dweck [6], students who see intelligence as fixed emphasize performance goals more ("looking smart"), whereas students with a growth mindset emphasize learning goals more ("becoming smart"). The former leaves students vulnerable to negative feedback and can lead to an avoidance of challenging learning opportunities, whereas the latter helps students to rebound from their mistakes [6]. A fixed mindset inhibits individuals from reaching their fullest potential by generating a fear of failure,

avoidance of challenges, and vulnerability to stereotypes such as "I am not a math person" or "math is not for girls" (e.g., [7–9]). Similarly, it has been found that students with a growth mindset are higher achieving during challenging school transitions, and their completion rates of demanding school courses are higher [10]. A growth mindset, either innate or taught, seems to lower adolescents' aggression and stress [11, 12] and enhances their school performance [13–17]. Furthermore, a national study from Chile has shown how poor school achievement is related to students' fixed mindsets [18]. A growth mindset also seems to temper the effects of poverty on academic achievement [18].

Earlier research on students' beliefs about the malleability of intelligence has produced some contradictory findings. Incremental beliefs about intelligence among Greek elementary and junior high school students did not correspond to school achievement [19] nor did these support a causal role for implicit beliefs in academic outcomes [20]. Instead, implicit beliefs about intelligence were found to be affected by prior school success and mediated by perceived academic competence [20].

Furthermore, implicit beliefs have been found to be domain-specific in nature [6]. Thus, it is possible to endorse an entity view of one construct and an incremental view of the other. One domain that has not been much studied thus far is that of implicit beliefs about giftedness. Dweck's incremental theory can be seen to be in line with the developmental theories and models of giftedness, which emphasize the changing nature of giftedness by highlighting different external and internal factors that contribute to gifted behavior [21]. For example, in their comprehensive *Talent Development Mega Model*, Subotnik et al. [22] discussed different delimiters and enhancers, including psychosocial factors, such as productive and unproductive mindsets. An unproductive mindset (i.e., a fixed mindset) is seen as an attitude that can "prevent coping with setbacks or thwart resiliency" ([22] page 34). Still, there has been little research on implicit beliefs about giftedness (cf. [23, 24]) compared to implicit beliefs about intelligence. The intriguing questions are whether the nature of these concepts is seen in a similar way and whether these views have similar effects on achievement.

Dweck ([25] page 312) suggests that it might be that the "word 'gift' itself implies that no effort is involved... and it is something that is bestowed upon the lucky few." This indicates that giftedness might be seen as more fixed in nature than intelligence. In their study, Laine et al. [24] examined Finnish teachers' implicit beliefs about giftedness. The results indicated that most of the teachers ($n = 463$) had a growth mindset about giftedness (54%), one-third (30%) had a fixed mindset, and the rest (16%) had a mixed mindset. However, the research made no comparison between implicit beliefs about intelligence and those about giftedness. In Finnish the word intelligence is often used traditionally referring to IQ, in other words, to logical-mathematical and linguistic competencies. Whereas the concept giftedness is used in more broaden manner, capturing all the other areas of giftedness as well [24, 26]. One study that contrasted implicit beliefs about intelligence and giftedness was made among high achieving American students. The research indicated that academically gifted students see giftedness more as fixed and intelligence more as malleable [23]. The research also indicated that even though there is a positive correlation between the natures of the concepts of giftedness and intelligence, the implicit beliefs of giftedness and intelligence cannot be regarded as synonymous [23].

Furthermore, most previous mindset studies have been conducted with adolescents or adults, even though a mindset develops early. We also know that students' mindsets at the beginning of lower secondary school predict their grades two years later [10]. Still, there is an evident lack of studies on elementary school students' mindsets, even though students at that age are already able to recognize and develop their motivational frameworks [27]. Thus, the present study provides a cross-sectional view of students' implicit beliefs from basic education through upper secondary school, covering age groups from 9 to 19. The precise research questions are as follows:

(1) How do school children and adolescents view the nature of intelligence and giftedness?

(2) How are school children and adolescents' perspectives on talent development related to their learning outcomes?

2. Context of the Study

This research has been carried out in the context of the Finnish school system. Overall, Finland's educational system has three levels: basic education (9-year-long comprehensive school, with an optional tenth year), secondary level (upper secondary school and vocational education), and higher education [28]. Basic education is comprised of elementary school (grades 1–6, age groups 7–12) and lower secondary school/middle school (grades 7–9, age groups 12–15). Upper secondary school provides general academic education typically for 16–18-year-olds. In elementary school, class teachers, who hold master's degrees in education, are responsible for teaching all subjects. In lower and upper secondary school, subject teachers have a master's degree in their respective subject(s), which are also the topics they instruct.

In Finland, basic education as well as upper secondary education is intended to foster the holistic growth of students, indicating that education involves not only the cognitive domain, but also the affective and social domains [29, 30]. Equality has been the core value of Finnish education since the 1970s. It has been concretized by providing equal opportunity for every student to be educated for free at all levels. In order to maintain societal equality, the emphasis has been on taking care of the weakest students, for example, those with learning difficulties [31]. However, equality in terms of acknowledging and providing equal learning opportunities for gifted students to develop their talents has been a neglected area in the Finnish school system [32, 33].

Another core value of Finnish education since the 1980s has been individualism. Individualism has meant that students' personal characteristics, needs, and interests should be taken into consideration in teaching [34, 35]. Since the Finnish school system is intended to be inclusive, most

Table 1: Participating students at the Viikki Teacher Training School.

	Basic education		Upper secondary school	Total
	Elementary school Grades 4–6 $n = 200$	Lower secondary school Grades 7–9 $n = 256$	Grades I–III(IV) $n = 151$	$N = 607$
Gender				
Female	98 (50%)	137 (54%)	102 (68.5%)	337 (56%)
Male	99 (50%)	117 (46%)	47 (31.5%)	263 (44%)
Mother tongue				
Finnish	168 (86%)	222 (87%)	143 (95%)	533 (89%)
Other	28 (14%)	32 (13%)	8 (5%)	68 (11%)
Academic achievement (min 5, max 10)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)
Math	8.88 (.94)	8.70 (1.13)	8.71 (1.20)	8.76 (1.09)
Finnish	9.16 (.84)	8.34 (1.12)	8.95 (.91)	8.77 (1.05)

students are taught in the same age group. The teacher's task is to create a learning environment that acknowledges the individual differences and learning processes for all students in the classroom [36]. Most recently, differentiated teaching has been described as the cornerstone of Finnish education [29]. Significantly, the 2014 curriculum takes into account for the first time gifted and talented students, which the curriculum conceptualizes as "talented pupils" ([29] pages 111, 139, 255, 405), indicating a change in the Finnish societal atmosphere in this regard.

Finland's success in the Program for International Student Assessment (PISA) was notable at the beginning of the 21st century [37, 38]. However, the two most recent PISA results have revealed that Finnish students' achievements have begun to decline [39, 40]. It has been speculated that one reason for this trend is that, in Finnish schools today, there is no will to confront situations or deal with content that requires students to move out of their comfort zones [41]. In other words, Finnish schools seem to foster a fixed mindset. Empirical studies also show that, in Finnish schools, intelligence and competencies are predominantly understood as relatively stable qualities, views that are nevertheless intertwined with malleable ones in the day-to-day realities of school life [42, 43]. For example, some Finnish teachers believe that the academic competence of poorly achieving students is malleable, yet that of high achieving students is stable [43, 44]. Other teachers' beliefs on this issue can be just the reverse [45].

The research for the present study has been conducted at the Viikki Teacher Training School of the University of Helsinki (hereafter called the Viikki School). The Viikki School functions as a teaching laboratory and includes approximately 940 basic education and upper secondary students and 110 members of the teaching staff. The Viikki School means to provide an optimal example and context for 250 student teachers per year to practice teacher planning, implementation, and evaluation under the guidance of in-service teachers. Basic education (grades 1–9) students at the Viikki School are local children from the neighborhood. The district can be characterized as a medium status, socioeconomic neighborhood in terms of income level, the education level of the original population, the unemployment rate, and the proportion of foreign-language speaking residents, as opposed to other low, fairly low, and high status neighborhoods in the metropolitan area ([46] pages 46, 53, 71). In addition to basic education, the Viikki School includes an upper secondary school for which students are selected based on school achievements. The Viikki upper secondary school students represent the top of Finnish academically oriented students. To be selected into the Viikki upper secondary school, students must have a remarkably high grade point average (GPA). In 2016, the lowest accepted GPA was 9.42, which in turn was the highest in Helsinki (on a scale of 4–10, with 4 referring to failing, 5 to the lowest grade, and 10 to the highest grade). In scores on matriculation examinations, the Viikki School is at the top of Finland's comparable schools; in 2016, student grades ranked fifth among all Finland's upper secondary schools.

3. Data and Methods

3.1. Participants. Students ($N = 607$) answered an online questionnaire under the supervision of their teachers. Most of the students identified themselves as either female ($n = 337$, 54%) or male ($n = 263$, 42%; Table 1). The students ranged in age from 9 to 19 ($M = 13.55$, SD = 2.47). The mother tongue of the majority (86%) was Finnish. The response rate was 83 percent (for grades 4–6, 91%; grades 7–9, 92%; and I–III, 64%).

3.2. Measurements. This study utilized Dweck's instrument ([6] pages 177-178), which measures beliefs about the nature of intelligence and giftedness as either malleable or incremental ([24], see also [23]). We used three original entity items (Table 2), which is designed for children over 10 years of age and adult respondents. We further applied and tested one adult item (item 3 in Table 2) in the entire sample. The participants were asked to evaluate their attitudes to eight statements on a six-point Likert scale (1 = strongly agree, 6 = strongly disagree), of which four statements were related to intelligence and four to giftedness. Higher scores indicated a malleable view.

In order to study the students' academic achievements, their grades in mathematics and the Finnish language were

Table 2: Factor loadings, communalities (h^2), and percentages of variance for principal factors extraction and direct oblimin rotation on mindset items.

		Principal component analysis			Confirmatory factor analysis
	N = 607	n = 295			n = 312
Item	M (SD)	Factor 1	Factor 2	h^2	Standardized coefficients
Mindset about intelligence	4.19 (1.07) α = .803				
(1) *You have a certain amount of intelligence, and you really cannot do much to change it.*[*]	*4.42 (1.26)*	−.02	.82	.65	
(2) Your intelligence is something about you that you cannot change very much.	4.09 (1.23)	.05	.84	.75	.81
(3) To be honest, you cannot really change how intelligent you are.	4.46 (1.29)	−.03	.79	.61	.81
(4) You can learn new things, but you cannot really change your basic intelligence.	4.03 (1.28)	.02	.77	.61	.73
Mindset about giftedness	3.60 (1.37) α = .931				
(5) You have a certain amount of giftedness, and you really cannot do much to change it.	3.69 (1.51)	.88	.07	.84	.87
(6) Your giftedness is something about you that you cannot change very much	3.52 (1.49)	.93	−.01	.85	.89
(7) To be honest, you cannot really change how gifted you are	3.66 (1.54)	.89	.02	.81	.92
(8) You can learn new things, but you cannot really change your basic giftedness.	3.51 (1.50)	.92	−.07	.79	.86
Percent of variance		52.07	21.65		

[*] Based on confirmatory factor analysis the italicized item was omitted from further analysis; scale of 1–6, higher scores indicate a malleable view.

computed from their school reports in 2016. The grades were not based on standardized tests; instead, they were a combination of tests, homework, classroom participation, and the teacher's evaluation of each student's effort. In basic education, a student's individual outcomes are compared only with his/her own previous outcomes, and the assessment is intended to be process-oriented ([29] pages 49-50). In upper secondary school, grades are also based on multiple kinds of evidence, including exams, discussions, and the teacher's observations [30]. However, in both basic education and upper secondary education, the evaluation is intended to assess students' knowledge and skills, not their personal characteristics. Nevertheless, in upper secondary school, the expectations and goals differ from basic education, and the courses and exams are academically more demanding. This might explain why the grades of the academically gifted Viikki upper secondary school students are seemingly lower than the basic education students' grades and lower than their entrance GPAs might indicate.

4. Results

To study the invariance of the measurements and whether the two sets of items are different from each other, first a principal component analysis was conducted for approximately 50 percentage randomly chosen participants (n = 295). Direct oblimin for oblique rotation was utilized, since it was assumed that factors would correlate [47]. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis on a good level, KMO = .831 ([47] page 685). Two factors had eigenvalues over Kaiser's criterion of 1. A two-factor structure appeared to be the most appropriate also based on the scree plot, which explained 73.72% of the variance. Factor loadings were between .77 and .93 (Table 2). The internal consistency of Dweck's items was studied with Cronbach's alpha values [48], which was .822 for implicit beliefs about intelligence and .926 for implicit beliefs about giftedness.

Secondly, a confirmatory factor analysis was conducted with the other 50 percentage of the data (n = 312) by AMOS 24 (Table 2). After the first intelligence item was omitted from the model, the *RMSEA* estimate of .096 was within the fit level of .069–.125 (Table 3), indicating mediocre fit [49]. Incremental fit measures showed that the proposed model exceeds the baseline model (NFI = .967, TLI = .969, CFI = .975, and RMR = .053). These results indicate satisfactory generalizability of the model. Reliability coefficients were for mindset about intelligence .823 and for mindset about giftedness .934.

Bivariate Pearson correlational analyses (Table 4) were conducted to investigate how students' implicit beliefs about intelligence and giftedness were related to each other, age, gender, and academic achievement in mathematics and Finnish language. The results showed that the implicit beliefs

Table 3: Goodness-of-fit values of implicit beliefs about intelligence and giftedness scale.

	Students (n = 312)
Absolute fit measures	
χ^2	50.318
df	13
p	.000
RMSEA	.096
90% CI	.069 .125
Incremental fit measures	
NFI	.967
TLI	.969
CFI	.975
RMR	.053

about intelligence and giftedness correlated moderately in the whole data ($r = .403$, $p < .01$). More specifically, as can be seen in Table 5, correlations between the two concepts were strongest among 9-10- and 11-year-olds ($r = .601$, $r = .547$, resp., $p < .01$). Also paired samples t-tests showed that youngest students, who were 9 to 12 years old, did not understand that the nature of intelligence and giftedness is statistically significantly different. Instead, older students made this distinction (Table 5). Further, age was positively but weakly related to implicit beliefs about intelligence ($r = .144$, $p < .01$) and negatively with giftedness ($r = -.114$, $p < .01$) (Table 4). One-way analyses of variance (ANOVA) showed that the variances between students from different ages were statistically significant ($F_{\text{intelligence}}(8) = 5.870$, $p = .000$, and $\eta_p^2 = .074$; $F_{\text{giftedness}}(8) = 2.794$, $p = .005$, and $\eta_p^2 = .036$). More specifically, pairwise comparisons (Table 5) located statistically significant differences related to intelligence between the youngest students (9–11-year-olds) and the 13–15-year-olds, the former ones having the most stable views of intelligence and latter ones the most malleable views. Regarding the nature of giftedness, 13-year-olds were the most growth-oriented toward this topic and differed statistically significantly from 16- and 17-year-olds, who scored the lowest, thereby indicating the most stable ideas about giftedness among the students.

With correlational analysis and a t-test, gender differences were established only for perceptions about the nature of giftedness ($t_{\text{giftedness}}(598) = 3.623$, $p = .000$, and $r_{Y1} = .149$), indicating that female students ($M = 3.77$; SD = 1.31) were more inclined to think giftedness as more malleable than male students ($M = 3.36$; SD = 1.41). No gender differences were found in implicit beliefs about intelligence.

The correlations were low ($r < .10$) between students' implicit beliefs and academic learning outcomes, and only the grades in mathematics correlated statistically significantly with implicit beliefs about giftedness. However, this correlation was negative.

Regression analyses with enter method was conducted to analyze whether implicit beliefs and background variables gender and age predict academic achievement in mathematics and Finnish language. As shown in Table 6, regarding mathematics age and implicit beliefs about intelligence and giftedness accounted for a significant but small amount of variance ($R^2 = .05$, $p < .001$). Younger age and a growth mindset about intelligence but a fixed mindset about giftedness predicted higher grades in mathematics. Regarding Finnish language only age accounted for a significant amount of variance ($R^2 = .03$, $p < .01$) indicating that younger age was associated with higher grades.

5. Discussion

This study investigated students' ($N = 607$) implicit beliefs about intelligence and giftedness. The study was conducted at the Viikki Teacher Training School at the University of Helsinki, Finland, which can be regarded as an ideal Finnish school with especially high quality teaching-studying-learning facilities. The participating Viikki students were in elementary school ($n = 200$; 9–12-year-olds), lower secondary school ($n = 256$; 13–15-year-olds), and upper secondary school ($n = 151$; 16–19-year-olds).

The results showed that students' implicit beliefs about the nature of intelligence and giftedness shared similarities but were also distinct. The nature of intelligence was seen as being more malleable than giftedness, and the result was in line with the study of gifted American high school students by Makel et al. [23].

Besides domain-specific variance, our study found age and gender related differences in students' views. Elementary school students who were 9–11 years old saw the nature of intelligence and giftedness as being relatively similar and stable. Older students (12–19-year-olds) seemed to make more distinction between the concepts, with intelligence being more likely to develop than giftedness, in line with the findings of Makel et al. [23]. The most fixed views about the nature of giftedness were among the upper secondary school students, who, having been accepted at Viikki, can be described as high achieving students. In general, the results seem to support Dweck's [25] argument that giftedness is more easily associated with fixed ideas, at least among older and male students. However, the connection between giftedness and fixedness is not straightforward, as was indicated by relatively high means and standard deviations (see Tables 2 and 5).

Despite the low effect size, our results verified the notion that mathematics is a subject domain that is particularly related to students' implicit beliefs [50]. By examining the relation between implicit beliefs about intelligence and students' academic achievements, it was found that growth-oriented views indicated higher grades in math. This result is in accordance with Dweck's [6] theory as well as a large body of empirical studies (e.g., [18]). However, to some extent it was surprising to find that fixed ideas about giftedness predicted higher math grades. Since this study is the first to investigate this relation, the result needs to be interpreted cautiously and more research is needed. The result indicates that the relationship between implicit beliefs and achievement might not be as straightforward as previous studies have suggested.

Table 4: Bivariate Pearson correlations.

	Implicit beliefs about intelligence	Implicit beliefs about giftedness	Age	Gender	Math
Implicit beliefs about giftedness	.403**				
Age	.144**	−.114**			
Gender	−0.013	−.147**	−.101*		
Math	0.059	−.097*	−.121**	−0.029	
Finnish	−0.063	−0.055	−.138**	−.318**	.461**

* $p < .05$; ** $p < .01$.

Table 5: Implicit beliefs about intelligence and giftedness among different age groups.

Age	N	Implicit beliefs about intelligence $\alpha = .803$		Implicit beliefs about giftedness $\alpha = .931$		r	Paired samples t-test
		M	SD	M	SD		
9-10	88	3.75[a]	1.22	3.59	1.36	.601**	$t(87) = 1.364$
11	68	3.79[b]	1.32	3.71	1.35	.547**	$t(67) = .542$
12	68	4.14	0.98	3.87	1.25	.291*	$t(67) = 1.631$
13	73	4.63[ab]	0.93	4.04[c]	1.25	.418**	$t(72) = 4.137$***
14	86	4.41[ab]	0.98	3.59	1.45	.390**	$t(85) = 5.462$***
15	76	4.42[ab]	0.82	3.56	1.45	.364**	$t(75) = 5.428$***
16	61	4.29	1.03	3.25[c]	1.3	.311*	$t(60) = 5.868$***
17	44	4.09	0.96	3.09[c]	1.21	.259	$t(43) = 4.958$***
18-19	36	4.18	0.93	3.41	1.42	.423*	$t(35) = 3.467$**
Total	607	4.19	1.07	3.6	1.36	.403**	$t(606) = 10.949$***

* $p < .05$, ** $p < .01$, and *** $p < .001$; scale of 1–6, higher scores indicate a malleable view; age group 9-10 included ten students who were nine-year-olds and age group 18 included three students who were 19-year-olds; means sharing the subscripts differed statistically significantly ($p < .05$) in pairwise comparisons conducted with Games-Howell's test (a, b) and with Tukey HDS's test (c).

Table 6: Regression analyses for predictors of academic achievement in mathematics and Finnish language.

	Mathematics			Finnish language		
	B	β	R^2	B	β	R^2
			.05***			.03**
Implicit beliefs about intelligence	.168	.168***		.074	.073	
Implicit beliefs about giftedness	−.198	−.197***		−.071	−.071	
Age	−.179	−.178***		−.154	−.156**	
Gender	−.079	−.079		−.073	−.073	

** $p < .01$; *** $p < .001$.

It should be also questioned whether the grade is the best indicator of academic achievement, as it is not an objective indicator and it seems that younger students achieve higher grades more easily than older students. Furthermore, this study raises the question of whether implicit beliefs about giftedness might reflect students' self-assurance in their skills. For example, among Greek 5th-6th grade students, implicit beliefs about intelligence did not result in higher grades in math or languages; instead, previous school achievements affected implicit beliefs and were mediated by perceived academic competence [20].

Even though this study supported the findings of previous studies, it also provided new aspects and questions about implicit beliefs, especially about giftedness. Because this is a case study from a single school and one that can also be described as a special school in a Finnish context, this research cannot be generalized to all Finnish students. Still, the results were similar to those found by Makel et al. [23] and could be explained by the fact that, in the Viikki School, students across all levels were relatively high achievers. Still, more research is needed from different contexts in Finland, since especially in the Helsinki metropolitan area, schools are

regionally segregated by socioeconomic class [51]. It has been shown that students with low socioeconomic or minority backgrounds are especially vulnerable to the effects of a fixed mindset about intelligence (e.g., [7, 8, 18]). The sample for this study was cross-sectional, providing an overview of students' implicit beliefs at a specific time. Thus, longitudinal research designs are needed to examine both the domain-specific (e.g., giftedness and intelligence) and the subject-specific (e.g., mathematics and language) nature of implicit beliefs as well as developments related to age. Furthermore, students' conceptions of intelligence and giftedness should be investigated further in order to determine how these concepts are constructed and to understand more about implicit beliefs and their role in talent development.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Hindawi
Education Research International
Volume 2017, Article ID 1357456, 9 pages
https://doi.org/10.1155/2017/1357456

Review Article

Creativity as a Stepping Stone towards Developing Other Competencies in Classrooms

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Received 23 February 2017; Revised 20 June 2017; Accepted 28 June 2017; Published 1 August 2017

Academic Editor: Doehee Ahn

Creativity, as a 21st-century skill, has gained more interest these past years and has become one of the key competencies to be implemented in classrooms. However, some studies highlight teachers' difficulties to integrate it in a classroom context. For instance, introducing creativity in overloaded school curricula may be a hindrance to developing it. Teachers have to implement other 21st-century competencies (the 4Cs) at the same time as well. These educational objectives can be considerable in terms of time and means for teachers and thus do not encourage them to develop these competencies. The purpose of this article is to present links, essentially theoretical, made by researchers between creativity and other 21st-century skills (e.g., critical thinking, metacognition, and collaboration). We considered that if creativity shares some characteristics with other competencies, it can be possible that, by applying only a teaching-for-creativity approach in classroom, we can also contribute to developing the other "C" as well. So choosing only creativity can be a way for teachers to develop their pupils' skills without falling behind in their curriculum. In this article, we will also discuss our hypothesis taking into account limits from teachers' classroom practices. Teachers' training, evaluation, and everyday practices will be considered.

1. Introduction

In France, the Bataclan and Nice terrorists attacks were by far the most terrible event that French people can report over the last decade. Shocking pictures and video footage of the attacks were everywhere on the internet and can be easily seen by everyone, even by youngsters. At this moment, one of the most raised topics was "how to explain the situation to children? How teachers can, in a proper way, talk about these events with the younger kids?" To answer these questions, the French government published on its website a list of advice to parents and teachers in a way to help them communicate the facts. The advice concerns attitudes towards children (listening to their fears, opinions) but also the need of clarifying the facts and warning them over rumors and manipulated information. Furthermore, some teachers chose to deal with the event by proposing drawing or writing activities in classrooms to allow children to express themselves.

In this context, more than ever, children may need some abilities to adapt themselves to the uncertain future. More specifically, developing new competencies is needed [1], allowing them to offer new solutions for a peaceful future. Creativity seems to be one of the core components of these new abilities and is considered as an asset for societal development [2]. Although creativity is widely recognized as an asset for society, it remains a fuzzy concept and there are many definitions of this competency in the literature [1].

For some authors, creativity is "a novelty that is useful" [3]; "the production of novel and useful ideas by an individual or small group of individual working together" [4]; or the ability to produce novel and adapted solutions in a specific context [5]. In these definitions, the focus is put on the produce and seem to lead on a general agreement of the nature of creativity [6]. For El-Murad and West [7], today most of the definitions of creativity combine the ideas of "novelty," "appropriateness," and "usefulness." In this article, we choose the present creativity as the process of having

original ideas that have value [8] and as an ability which can lead to major discoveries or simple creative production in everyday life [9].

The main objective of this article is to review the literature on creativity taking into account the other 21st-century skills. The P21's Framework for 21st-Century Learning was developed in order to present the skills and knowledge needed for students' success. This project, designed with the help of US teachers and business and educations experts, highlights various subjects such as the "content knowledge and 21st century themes" (e.g., sciences, arts, financial literacy, or global awareness), the "learning and innovation skills" (e.g., the 4C: creativity, critical thinking, communication, and collaboration), the "information, media, and technology skills" (e.g., working with the 21st-century technologies and innovations), and the "life and career skills" (e.g., social and emotional competencies to succeed in life and work environment). Currently, this framework is more and more used in order to change school curriculum in Europe and encourage teachers to develop these abilities in order to prepare children for an uncertain future and increase the chance of major discoveries and societal and economic prosperity [10]. So, in this context, we chose to focus our literature review based on this framework. We chose to focus on creativity because this ability is used by children in early stages of development and can be measured even in youngsters [11]. Indeed, children used it naturally to adapt themselves in everyday situations of their lives [9].

Our main hypothesis is that the introduction of creative practices in classroom can possibly lead to developing other competencies of pupils at the same time. In other words, we consider that working on creativity alone, if it is done in a meaningful way, may contribute to some extent to develop the other 21st-century skills as well (an all-in-one approach to the matter). We know that developing creative potential takes time and patience [9] but if teachers have a better understanding of the nature of creativity and its possible links with other important competencies, we hope that teachers will be reassured and integrate more easily creative teaching in class and so will aim to develop the other competencies of children as well.

For this purpose, we will present, first, a brief definition of creativity in educational settings and after that a review of the literature based mostly on the theatrical link between creativity and critical thinking, between creativity and metacognition, and, last, between creativity and collaboration skills. Finally, we will discuss these findings considering teachers' training and the nature of classroom activities.

2. Creativity in Education

Nowadays, the benefit of developing creativity in classrooms is widely recognized by education professionals [12]. Introducing creative teaching in classrooms can bring benefits such as developing children's imagination and increase the probability for major discoveries and economic development for the future [1]. Also, creativity is considered as an important component of personal well-being [13] and in a classroom context may develop curiosity, openness, and communicational abilities [14].

Actually, there are several theories of creativity and numerous variables that are involved in creative potential [11]. These numerous theories or variables can be confusing for teachers [12]. Indeed, the study shows that teachers have difficulty understanding and giving a clear definition of creativity despite the fact that they can understand the importance of creativity in education. So, in order to help teachers understand how to introduce creativity in classroom, we will first define the theoretical background of this concept through an approach that takes into account individual differences, the multivariate approach [15].

3. Creativity Multivariate Approach [9]

The multivariate approach defines four main components for creativity: a cognitive factor (e.g., intelligence or knowledge), a conative factor (e.g., personality or motivation), an emotional factor (the impact of emotional traits on creative potential), and an environmental factor (e.g., familial of school environments). In this article, we chose to put an emphasis essentially on the link between the 21st-century abilities and two factors: the cognitive and environmental ones. This choice is motivated by two considerations, first the cognitive factors can be trained in classroom through the school curricula and the environmental school factor can be changed through management made by teachers. The personality and emotional impact on creativity are needed but we considered the cognitive and environmental as a first objective for teachers considering existing evidence and techniques in the literature that can be introduced in everyday teaching. However, in order to help our lecturer to better understand the nature of creativity, we present all four components of the multivaried approach.

For the cognitive factors of the multivariate approach, there are many components whose impact on creativity can be studied. First, divergent thinking, consisting of the ability to produce many solutions from a situation [5], is an essential ability involved in creativity; next, there is the convergent thinking defined as the capacity to consider the demands of the environment and produce a unique and original solution based on several ideas. Convergent thinking involves the ability to associate different ideas, evaluate them, and combine them into a new, original production [16]. Also, Lubart et al. [5] specified other skills involved in creative potential such as the evaluation of ideas, the capacity to select the relevant ideas and to put aside the irrelevant ones or mental flexibility defined as the ability to consider an idea through different angles and also to deviate from one idea to consider another to propose creative solutions.

Conative factors have an impact on creativity. Some ways of behaving have been identified and characterized by creative individuals. Lubart and colleagues [5] cite several of them, including personality traits, cognitive styles, and motivation. Cropley [17] presented a list of common personality traits involved in creative potential of individual such as independence, openness to experience, flexibility, and tolerance of ambiguity [18, 19]. Concerning the creative

personality in youth, Callahan and Missett [20] were able to establish a number of characteristic traits of creative adolescents such as a rejection of social conformity; desire for independence; attraction for novelty; an important imagination taste for risk; and greater perseverance in the face of obstacles and ambiguous situations. Also, regarding the influence of motivation, Amabile [21] found that creativity is based on intrinsic motivation and children with extrinsic motivation tend to be more conformist.

Concerning the emotional factor of creativity, emotions have an impact on individual creativity [22]. Shaw [23] indicates various feelings involved in the "joy of creation" such as fascination, self-confidence, frustration, relief, excitement, and satisfaction. Also, Zenasni and Lubart [22] indicate that the emotional intensity (e.g., intense emotional state can enhance creative potential of artist), the nature of the creativity task (the relation between creativity and emotion may vary depending on the task), or the emotional traits of individual (e.g., the ability to identify emotions) modulates the effect of emotions on creativity.

Finally, the environmental factor of creativity refers to the familial environment (e.g., an open and nourishing environment where children can explore and share ideas) but also to the school environment [11]. The impact of the environment is crucial for developing creativity [2]. Indeed, it is easier to practice creativity when the circumstance allows it [11]. Craft [24] indicates that school environments provide children a frame for developing creativity by allowing them to ask questions, share opinions, and engage in critical and evaluative thinking practices. In a literature review, Davies et al. [25] also provide some examples of practices for developing creativity in school environment such as flexible use of space and time; working outside the classroom; respectful relationships between teachers and learners and nonprescriptive planning.

So aiming for creativity other than competency may be more natural to children and less difficult to introduce to them than other competency (e.g., critical thinking, metacognition, or cooperation working).

4. Children Creative Potential

The ability to produce novel ideas is referred to as the creative potential. Creative potential refers to the individual's possibilities taking into account the cognitive capacity, personality, motivation, and the environment [11]. Considering the development of creative potential, it can change over time and the potential will vary depending on the domain and the task [2].

Beghetto and Kaufman [9] proposed four levels of creativity that describe individual's creative productions such as "Big C" level which refers to the eminent creative person (e.g., Einstein) and "Pro C" individuals expert in their fields (e.g., a scientist, a painter). In everyday life, the authors distinguished two levels: "little-c" considered as creative by their peers (e.g., winning a school contest) and "mini-c" individuals who use creativity for learning (e.g., learning insights). Children show mostly "mini-c" or "little-c" [9]. The benefits of "mini-c" or "little-c" activities in education are numerous [26], including meaningful learning, reducing stress, or a better engagement in learning activities.

In an ecological context and considering the variations of the multivariate approach factors in everyday situations, we consider that the main topic regarding creativity in classroom is not student's performance but mainly their ability to know what is creativity and how to use it in a meaningful way. We saw previously that the school environment can promote the use of creativity and teach children about creativity. Also, a common distinction is made between "teaching creatively" and "teaching creativity" [24]. Teaching creatively refers to the ability of the teacher to make learning more interesting by using creative approaches; teaching creativity is defined as teaching methods with the purpose of developing students' creative thinking [27]. The N.A.C.C.C.E report [28] indicates a close relationship between these terms and also that teachers' creative abilities are engaged when teaching for creativity practices. Hence, we chose to develop this article in terms of a "teaching for creativity" perspective considering that it can inspire practices of teaching creatively as well.

5. Teachers Role in Promoting Creativity

For promoting creativity, the role of teachers is crucial [29]. Indeed, teachers' beliefs towards creativity or students abilities may affect the development of their creativity [9]. Teacher's impact on the development of creative potential is known and their attitudes towards children potential are important (e.g., high expectations, support, open attitude, and tolerance to ambiguity) [30]. However, despite the essential role of teachers and the numerous benefit of creative teaching, creativity is not much integrated in classroom curriculum.

Cachia et al. [12] conducted research on teacher's perception of creativity and the teaching practices that enhance creativity and innovation in classroom. In their research, they gathered the opinion of (mostly) primary and secondary school teachers from 37 countries in the European Union. To collect their data, they used various means such as interviews with experts in the educational field, analyses of 1200 curricula documents, and online surveys. Results indicate that even if teaching for creativity can be mentioned in school curricula from many countries, it does not mean that schools are developing creative practices. Also, they highlight the fact that teachers do not have a clear understanding on how should creativity be defined or how it should be introduced in classrooms (as learning or assessment), even though teachers recognized the importance and interest of teaching for creativity.

Sternberg [1] provided a brief historical overview of the development of creativity in the research field and in education. Since Dewey's [31] or Guilford's [32] argument for creativity until today, education does not seem to have significantly changed. In fact, Braund and Campbell [33] found that curriculum and assessment goals or time pressurized teachers create a difficult climate to introduce creative practices in classrooms. Also, creative thinking cannot be taught by "showing slides and talking about theory" [34]. It needs specific activities that can be domain general or domain

specific. Beghetto and Kaufman [9] are well aware of teacher's fears and to reassure them, they highlight the fact that there are moments and contexts for creativity.

6. The 21st-Century Skills

Binkley et al. [10] suggest a list of the 21st-century skills in order to help teachers and educators to implement it in classroom context. They divided the "learning and innovation skills" from the P21 Framework into groups. So creativity, critical thinking, and metacognition (learn to learn) are considered as "ways of thinking" and communication and collaboration as "way of working." In summary, creativity is a part of the 21st-century skills, alongside with critical thinking, metacognition, communication, and collaborative skills [35]. Communication skill, as defined by the P21 Framework, is the ability to use oral, written, and nonverbal skills to share thoughts and ideas in a wide range of situations. Felder and Brent [36] defined collaboration learning as a group of individuals (or students) working in teams under conditions where members of the group will be responsible for the content of their work and are willing to work together. Also, Ras et al. [37] defined collaborative problem solving as an ability to address problems in a collaborative setting. Members of the group will need to exchange knowledge and strategies to fulfill their mission.

Bensley [38] described critical thinking as a multidimensional construct with skills like decision making or problem solving. There are various definitions of critical thinking skills but a consensus has been reached over its definition [39]. Also, from one author to another, it is possible to observe the absence or presence of certain subskills. These subskills include observing the different facets of a problem [40]; analyzing arguments, evidence, and beliefs [39, 41, 42]; producing inferences [39, 40]; evaluating arguments [39, 43], and making decisions [40, 41, 43]. According to the authors considered, it is possible to observe that the definitions of cognitive abilities may be accompanied by dispositions [44]. The critical thinker dispositions were for the most part considered in a philosophical context although some of them could be used in the cognitive sciences field. Among the frequently observed dispositions in the literature, some are frequently highlighted [39, 41, 42] such as curiosity, openness, and flexibility in considering the opinions of others, valorization of alternative opinions, and the ability to reconsider its opinion.

Finally, for Sanz de Acedo Lizarraga and Sanz de Acedo Baquedano [45], metacognition means the knowledge of cognition and the regulation of cognition and action. Flavell [46] defined metacognition as the knowledge that individuals have of their proper cognitive process and their products. According to Flavell [46], metacognition is presented through three phenomena: metacognitive knowledge, metacognitive experiences, and metacognitive skills [47]. These researchers present metacognitive knowledge of person, task, and strategy; metacognitive experiences as a range of feelings (perception of difficulties, satisfactions, or confidence) and judgements or estimation of effort or quality of learning; metacognition skills as the use of strategies in order to monitor cognition.

Hence, teachers need not only to teach about creativity in the classroom but also to implement other competencies in the same curriculum at the same time, which can put them in a stressful position. Now, we are going to present the theatrical elements of the literature that indicates links between these skills. Also, we choose not to develop the communication skills and focus mostly on the thinking skills and the collaborative way of working. This choice is motivated by the fact that the communication skills can be developed alongside the other competencies. For example, during the process of problem solving, pupils can share thoughts, ideas, and their points of view on their task, which can be seen as collaborative and critical thinking tasks where pupils are using their communication skills. Also, the use of communication skills depends on children's literacy which is already more developed in the classroom than the other competencies.

7. Creativity and Critical Thinking

Creative and critical thinking are two competencies that gained more and more attention these past years, especially, since the need to develop information and communication technologies in school. In fact, the digital revolution brings new problematics for education, notably, the impact of new technologies mean frequent changes in everyday life and the need for individuals to adapt to these situations. Also, the use of internet by children means that they need to select information from numerous sources and know how to use the information in a useful way.

Critical thinking has been defined in a philosophical and a psychological way by many authors [48]. Because of its numerous definitions, it can be considered as a fuzzy concept [48]. In fact, in a psychological point of view, researchers focus mostly on the cognitive processes involved during the critical thinking procedure whereas philosophers are interested in the value of the critical arguments [49]. The cognitive perspective implies various processes that compose the critical thinking process [49] and that can be observed in an educational context. Bloom's taxonomy of educational objectives [50] organizes instructional mental activities depending on their difficulty level in a classroom context (e.g., going from basic to higher order mental operations). For high-order level skills, Bloom [50] refers to analysis, the ability to organize and compare information, synthesis, gathering together information and evaluation, and making judgements on information.

These mental operations can be observed in the literature on creativity. Cropley [17] defined nine conditions where teachers can develop their pupils' creativity. For example, he advises teacher to let children make their own judgement and evaluate their creative products and by providing them more time for self-evaluation. The main reason lies in the fact that in this way pupils have more time to elaborate, formulate, and adjust their ideas and become more autonomous, a quality needed for creativity to develop. In fact, by being

autonomous, children construct their own idea of what they want and make and are more tolerant to ambiguity without strict norms that can lead to noncreative productions [51]. Also, by allowing children to ask more questions in the classroom, teachers can guide them to explore the possible answers to their questions alone or with their classmates and lead children to develop more flexibility, collaboration, and a better sense of self-evaluation. Also, mental flexibility is considered as an essential asset for living in the 21st century [51] and as an essential part in creative thinking [11]. As we defined it earlier, cognitive flexibility is essential to find various solutions to one problem or considering one problem through different angles [52]. Additionally, for creative convergent thinking, the ability to evaluate various ideas and choose the more appropriate one (make judgements), critical thinking is needed [11] and some research suggested that critical thinking implicates better judgements [53]. Finally, Dwyer et al. [48] presented critical thinking as a skill that should be more highlighted in educational setting. In fact, they argued that children should be trained to use more their critical thinking abilities in real-world problem in order to become more adaptable to the rapid development of the 21st century.

Some articles mentioned also the link between creative personality and critical thinking. For instance, Bailin et al. [54] considered that critical thinking in primary schools promotes the development of an open-mind. As well, Sternberg [55] described a critical thinker as someone who is open-minded, understands various points of view, and is flexible. Florea and Hurjui [43] exposed the same idea, considering that for developing critical thinking children need to have a tolerant mind.

Finally, considering the classroom context, Blamires and Peterson [56] present various ways of assessing creativity. In the assessment for learning techniques, some strategies to help teachers implement creativity in the classroom involve "questioning, exploring ideas, and having various options or reflecting critically on ideas, actions, and outcomes." Florea and Hurjui [43] defined critical skills as a way of solving problems by "verifying, evaluating, and choosing the right answer to a given task and reasoned rejection of other alternatives solutions." Also, Craft [24] recommends techniques for developing creativity in the classroom. One of them refers to the need for teachers to establish link between concepts, make children reflect on possibilities and solutions for one problem, and explore and think critically over their ideas.

So, considering these researchers, we argue that creativity and critical thinking are needed and also that these two skills are linked. We cannot assume based on the literature that developing one of them (creativity) can be sufficient for developing the other (critical thinking). However, with the theatrical background presented, it can be possible to consider that they are present alongside in some situations and share some processes, and so maybe using one can contribute to developing, in a certain way, the other.

8. Creativity and Metacognition

Metacognition skills can develop at the same time as creativity. Indeed, Sanz de Acedo Lizarraga and Sanz de Acedo Baquedano [45] argue that creative thinking can be considered as a part of metacognitive processes because a person has to monitor his thinking skills during the production of a new and useful idea. Also, during the creative process, an individual must check his or her strategies and adjust them if needed in order to increase creative output. Sanz de Acedo Lizarraga and Sanz de Acedo Baquedano [45] referred to Jausovec [57] who described metacognition as an ability needed mostly for convergent thinking which is part of creative problem solving. Sanz de Acedo Lizarraga and Sanz de Acedo Baquedano [45] explained that the link between creativity and metacognition is less explored because of the difficulty to assess it; this is mostly due to the measure of the incubation stage of creative process, a stage where ideas are associated unconsciously. Sanz de Acedo Lizarraga and Sanz de Acedo Baquedano [45] conducted a study to measure the link between creativity and metacognition. To assess it, they used a divergent thinking task combined with a metacognition scale for creativity. This scale measures the knowledge participants had on their thinking process or the task and their regulation of cognition that refers to the regulation of their behavior during the creative task. The result of the study shows a positive correlation between total creative potential and total creative metacognition and also presents metacognition as a predictor of total creative potential ($r = .66$, the coefficient of determination (R^2) indicates that metacognition explained 45% of variance of total creative potential). So this research contributes to showing a positive link between creativity and metacognition and emphasize the importance of considering metacognition alongside with creativity.

In the classroom context, other authors, like Besançon and Lubart [11], recommend that, in order to develop creative thinking, teachers should encourage children's self-evaluation of their ideas and improvise courses with the purpose of allowing pupils to construct and develop their knowledge and use metacognitive reflection. Also, Sternberg [58] found that metacognition abilities were linked to creative problem solving. In the arts, a high level of metacognition is correlated with a creative production and children's play (a determinant activity for developing children creativity) increases the level of children's metacognition.

Finally, Beghetto and Kaufman [9] argue that children need to know when to be creative. Indeed, these authors highlight the fact that creativity is often seen as totally beneficial. Although this consideration is true regarding the fact that creativity can contribute to innovation and adaptation, there may be negative impact of using creativity in some circumstances. These negative impacts include personal and social risk. Beghetto and Kaufman [9] defined personal risk as wasting time, bothering others, and being ignored or misunderstood. In the classroom context, creativity can appear anytime during the lesson and bring as well these negatives impacts. Considering these effects, Kaufman and Beghetto [26] propose the concept of creative metacognition

(CMC), defined closely to Flavell's one [46]. CMC is seen as a combination of creative knowledge about ourselves (e.g., creative strength and weakness, past experiences) and knowledge about the context in which creativity can occur (in general or in a specific domain). Thus, mastering the concept of creative metacognition in a teaching context can be an effective way to develop at the same time creativity and metacognition.

9. Creativity and Collaboration

Finally, collaboration refers at the same time to the 21st-century skills but also to a method sometimes used in classroom [59]. This skill presents an interest mostly because collaborative work is a way of teaching generally appreciated by pupils helping them to find different solutions to a new problem, to express different opinions, and to be more engaged in tasks [60]. Despite the fact that collaboration is often cited as an interesting skill for developing creativity, to our knowledge, a few studies exist that highlight the link between these competencies.

Navarro-Pablo and Gallardo-Saborido [61] presented some benefit of cooperative work, such as deeper understanding of the task and development of interpersonal skills or critical thinking skills. Slavin [59] mentions the fact that collaborative learning may increase cognitive abilities such as their learning abilities and lead to better performance on the task. Lucas et al. [51] add that creativity can develop better social and emotional skills through the practice of collaboration. Yates and Twig [62] review practice enhancing creativity potential in a classroom context. One of them refers to the classroom environment and more specifically to children's communication skills. The authors argue that better communication between children will lead to the production of new ideas and solving problems. Finally, Besançon and Lubart [11] recommend that teachers in order to develop creativity offer the possibility of pupils to work together and to encourage students to help each other as much as possible.

Collaboration skills are almost always considered as interesting skills to develop creativity. However, taking into account the French education system, the more children are growing up, the less they have the possibility of working together and also French teachers rarely used collaboration techniques (nearly 37% of them) [63]. The main reason concerns the way assessments are made in the classroom and the way the tasks were assigned. For example, although children are asked to work together, we cannot be sure that they fully understand the purpose of this way of working and also do not think that collaboration means only working with at least another classmate. Hence, we cannot be sure that children understand the cognitive and social benefits of collaboration and that the practice of collaboration will develop any skills.

10. Discussion

Through this literature review, some limits about the findings can be highlighted. Indeed, most of the studies presented are the theoretical points of view of researchers who have worked on creativity, critical thinking, metacognition, or cooperation. Few empirical evidences (to our knowledge) about the link between creativity and other skills exist and are drawn from class situations. Also, we know that although these variables can be correlated, we cannot explain a causal relationship between them. So we do not really know which one is the cause and the effect. This is one of the limitations of the actual literature. We strongly recommend that teachers try to introduce creativity into their classroom to see if there are other effects on other skills but we insist that our recommendations are based on theoretical findings mostly. As well, even though these variables will have an effect on another, we cannot know to what extent and predict the strength of these effects. Thus, the need to conduct research on the issue is more than highlighted. This lack of evidence has prompted us to choose only numerous theoretical evidences in order to encourage other researchers to go deeper into this subject and so consider studying in the classes the link between the 21st-century skills and their causal relationship. Also, this literature review made it possible to elicit the following reflection: in the educational context, it is frequent to target studies working on a competence itself or sometimes two but can we really consider the school environment as one or two variables at a time? The necessity to go out of our laboratories and study in classrooms the everyday life of pupils and their teachers, who alternate or combine situations involving critical thinking, creativity, cooperation, or metacognition, seems paramount. It may be also interesting to study the cognition of teachers in classroom situations and observe the means by which they try to introduce practices and see which ones succeed and which ones fail. For instance, we can observe the way they integrate some creative moments in the classroom, the way they give feedback to their pupils, or why some practices are preferred by teachers over others. We should also see if teachers tend to implement one competency over the others and why? If so, it does not matter which competency is chosen; what matters is the optimization of the skills to develop the others.

About the teachers practices, some limits can be highlighted too. First, Cachia et al.'s [12] study offers another interesting result; teachers who have the greatest interest in creativity or innovation are also the ones with many years of experience in education. This result may be surprising considering Sternberg [1] point of view on teachers training. In fact, Sternberg [1] proposed to change teacher's training for the following reason: the former teachers have become the trainers of the new ones and so the traditional way (e.g., summative assessment, passive learning) of teaching persists, which is not useful for the development of creative practice or other competencies. So, considering these opposite findings and the fact that new generations of teachers, those born at the end of the 20th century (the 90s) and having grown up with the problems of the 21st century, can be less interested in innovation than the older ones, new research about teachers' practices are needed. The impact of initial teacher training needs to be observed and measured. It will be interesting to see if, as Sternberg says, new teachers will continue to adopt a traditional way of teaching.

Also, even if the new or experienced teachers learn about 21st century competencies, how can we be sure that they will become efficient in transmitting these 21st century skills? To answer this question, first, it can be useful that researchers who work on 21st competencies combined their effort with teacher trainers, to integrate in their curriculum training on competencies and measure the impact of this training before thinking of bringing it into classrooms.

Another interesting topic concerns the way of assessing those competencies in classroom contexts and curriculum. First, adding those skills in school curricula will involve the need for teachers to assess the progress of their student and the mastery of these skills. The traditional way of assessing knowledge, the summative assessment, the classical way of assessing by rating student performance, is probably not the optimal way of rating these skills. Mainly, summative assessment is related to significant deficiencies such as superficial learning and the failure of transferring learning over situations. However, formative assessment, assessment by feedback with the aim of helping student progress, is considered as a stimulating practice for pupils' imagination, allowing an open dialogue between teachers and students and more engagement in learning [56]. Also, regarding assessments, most of them, at least in the French school system, are based on individual ones rather than group tasks; we can assume that this way of assessment is preferred because it seems to be easier for teachers. So the need for change in assessment is crucial to introduce 21st skills in classrooms.

To help answer a few of these issues, we will follow new graduate French students from their last year in teachers' training academy to their first step as primary teachers and follow them for the next three years. Half of them will study the 4C competencies presented in this review. Students will study these skills through online materials, which will also be used in class by their trainers. These online materials aim to define skills in order to help students to better understand and use them. These competencies will also be discussed during their training to help them reflect on their practices and consider ways to implement these skills in classrooms. Their 4C competencies will be measured quantitatively (using tests) and qualitatively (observation made in classroom, practice follow-up notebook) during each year to see the change of teachers and pupils practices. Also, teachers' efficiency in their practices will be assessed and analyzed through filming everyday teaching class and collecting some of their teaching materials and through interviews of their perception of their training and their practices.

With this protocol, we will see if a change in teacher's training will be effective to implement the 4C and also to obtain some directions to understand the classroom context for developing in an effective way the 21st-century competencies. We will also have a better insight of everyday class situations and the problematics that young teachers encounter. Finally, we will analyze our data based on (a) the links between these variables but also and above all to study (b) the causes and the effects of the introduction of these variables in classrooms.

11. Conclusion

The purpose of this review was to provide teachers with some arguments that creativity is linked to the other 21st-century competencies. We hope that this article will provide insights and ideas for educators and will encourage them to explore the impact of implement competencies at the same time or through the use of one skill to see the effects on the others ones.

Also, we would like to emphasize that, in the literature, there are few articles on these topics and even less empirical ones. The report is the same regarding the use of the 4C and ICT (Information and Communication Technology). We hope that, in the future, more ecological research will focus on the reality of the classroom context and see how research-validated techniques can facilitate the daily issues that teachers encounter.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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