Journal of Research in Education and Pedagogy
ISSN 3047-7131 (online) & 3047-6410 (print)
February 2025, Vol. 2, No. 1, pp. 26–37

Research Article

Creative Thinking in Science: Influence of Ethnicity, Gender and Grade Level in Co-educational Schools, Kenya

Richard Owino Ongowo[1]

[1]Department of Educational Communication Technology and Curriculum Studies, Maseno University, Kenya

Abstract
The purpose of the study was to investigate the influence of ethnicity, gender and grade level on creative thinking in science among co-educational secondary school students. The study employed cross-sectional design with purposive sampling through which 363 students were sampled from 2 co-educational secondary schools in Kakamega (n = 198) and Siaya (n = 165) counties of Kenya. The entire sample was made of grade 9 (n = 95), grade 10 (n = 99), grade 11 (n = 75), and grade 12 (n = 94) students. The same sample consisted of 168 males and 195 females. Students Science Creativity Questionnaire (SSCQ) was adapted from Smith (2019), piloted and used to measure creative thinking in science. The instrument measured four dimensions of divergent creative thinking as fluency, flexibility, elaboration and originality. The data were analysed using a 4 x 2 x 2 MANOVA. The findings indicated statistically significant ethnic differences between Luo students from Siaya county and Luhya students from Kakamega county with regard to fluency and flexibility in favor of Luhya students. There were no statistically significant gender differences in creative thinking in science and statistically significant grade level differences in the dimensions of fluency, elaboration and originality. The findings have implications for pedagogic practice. Science teachers could deliberately make learning environments characterised creative learning activities which require learners to to generate multiple ideas and encourage students to solve scientific problems. Such learning environments could be made to encourage gender inclusive pedagogic practices and tailor creative learning experiences to grade level of learners. The discussion, conclusions and recommendations of the study are herein explained.

Keywords: Creative Thinking, Ethnicity, Gender, Grade Level

Correspondence
Richard Ongowo
ongoworichard@gmail.com

Received
July 24, 2024
Accepted
December 26, 2024
Published
February 3, 2025

Citation: Ongowo, R. O. (2025). Creative thinking in science: Influence of ethnicity, gender and grade level in co-educational schools, Kenya. *Journal of Research in Education and Pedagogy, 2*(1), 26–37.

DOI: 10.70232/jrep.v2i1.17

1. INTRODUCTION

Creativity is a human construct that has existed since antiquity. However, its significance has gained traction across the globe in the last five decades (Plucker, Beghetto & Dow, 2004). In response to this, educational systems across the world have aligned their curricular objectives towards developing this trait (Shaheen, 2010; Cheung & Lau, 2013; Kyunghwa & Hyejin, 2016; Ahmadi & Besancon, 2017); Kozlowski, Chamberlin & Mann, 2019; Shao, Zang, Gu & Yuan, 2019). According to Plucker et al. (2004) and Shao et al. (2019) much significance has been attached to this construct since it is a key engineer for facilitating social harmony, sustainable human development, technological invention and scientific revolution. Choi (2004) holds that creativity has been identified as a source of organizational innovation. According to Ahmadi and Besancon (2017) creativity is a 21st century skill that learners require to survive in life after school and in the world of work. Shao et al. (2019) notes that Creativity is a product of culture and enriches culture.

Despite the celebrated significance of creativity, it remains a challenging construct to define with varied definitions in literature and absence of consensus or unity in its conceptualization (Ahmadi & Besancon, 2017; Shao et al., 2019; Kozlowski et al., 2019). To indicate the extent of definitions which have come to the fore, Shao et al. (2019) have noted that a plethora of definitions exist that have been compiled

into a book. Lee et al. (2015) observe that due to a multiplicity of conceptions of creativity that are available and lack of consensus and universality regarding such definitions, individuals across cultures sometimes use context or culture specific theories of creativity as general theories or definitions. Sternberg and Lubart (1995) defined creativity as the process of generating ideas that are novel and bringing into existence a product that is appropriate and of high quality. According to Choi (2004), Creativity is the generation of novel or original ideas that are useful or relevant. Amabile (1988) defines creativity as the production of novel and useful ideas by an individual or a small group of individuals working together. Ma (2009) defined creativity as the ability to recognize the available knowledge, information, cues, facts, and /or skills in a person's reservoir to generate new ideas or useful solutions. According to Runco and Jaeger (2012), Creativity has a bipartite meaning of both originality (novelty, uniqueness, non-conventional) and effectiveness (usefulness, appropriateness and value). These two characteristics define creativity. Rhodes (1961) conceived creativity to be composed of four components (4 Ps) as person, process, product and press (environment). Plucker, Beghetto and Dow (2004) consolidated these components into a definition as the interaction among aptitude, process and environment by which an individual or group produces perceptible product that is both novel and useful as defined with a social context. In the present study, creativity is perceived as an intrinsic mental expression which enables an individual to produce novel, original, and appropriate thoughts.

According Kim (2009), most factors affecting creativity have a relationship to a person's environment or culture in which a person exists. Sternberg (2006) has noted that creativity is a confluence of personal variables and the environment. A cultural environment represents a set of shared systems which can inhibit or stimulate creative expressions. Shao et al. (2019) have argued that creativity has an extremely intimate and complex relationship with culture and at the same time is deeply embedded in all cultures with its attributes varying across cultures. Tommassoni, Treglia and Tomao (2018) while stressing the significance of culture and creativity noted that creative acts express a place and cultural time as well as the personal heritage that defines its character. They continue to aver that creativity reflects the characteristics and options offered by the environment from which it emerged.

According to Naderi et al. (2009), gender is one of the most important background characteristics of creativity in educational literature. Cheung and Lau (2013) opine that comprehensive reviews of creative thinking and divergent thinking have revealed no consistent pattern in gender differences in creativity test scores. Taylor et al. (2023) have observed that minimal gender differences exist in creative ability but substantial differences exist in the creative achievement of men and women. Although majority of studies have revealed gender differences, these have been attributed to a multiplicity of factors such as culture, the environment, problem types, scoring methods, data analysis approaches or combinations of these factors (Baer & Kaufman, 2008; Hong et al., 2013; Cheung & Lau, 2013). Runco, Cramond and Pangani (2010) continue to observe that the ability of both genders to translate creative potentials into actual creative achievements depends on factors such as opportunities, personal and social resources and inter and intra personal expectations.

Development of creativity in children and adolescents has been a topic of continuous research in the field of education for more than 5 decades (Lau & Cheung, 2010; Hemdan & Kazem, 2019). However, the results of these trend studies have not been definite. According to Kim (2011), many studies have concluded that a large drop in creativity and curiosity occurs when socialization and conformity is initially taught which in western societies begins in the 4th grade. According to Hemdan and Kazem (2019), the trend studies have produced mixed results with different models of development for instance, some studies have yielded linear trends, others have produced J-shaped trends in grades 5-9, others have produced inverted J-shaped trends from grade 1-5 and U-shaped trends from grades 3-5. Charles and Runco (2001) continues to aver that when these developmental trajectories of creativity are examined, they often indicate slumps and peaks and sometimes more of each. Barbort, Lubart and Besancon (2016) opines that methodological limitations exist when studying creativity development and contribute to inconsistent findings. These limitations include small sample sizes, selection bias, and use of cross-sectional design.

1.1. Models and Theories of Creativity

Since the inception of creativity studies, a number of models and theories have come to the fore. Some of these theories include the following. Firstly, Four P framework was synthesised by Rhodes

(Rhodes, 1961) after reviewing existing literature to see how creativity was being studied. He came up with four primary categories known as the 4 Ps Person, Product, Process and Press (environment). The 4 Ps represent four possible questions as: what type of person is creative? What is considered to be creative? How do we create? How does the environment shape creativity? Secondly, The 5 A framework was proposed by Glaveanu (Glaveanu, 2013) which conceptualises creativity to involve Actors, Audiences, Actions, Artefacts, and Affordances (or material resources). This framework focusses on the interrelations between various elements of creativity. Thirdly, Beghetto and Kaufman (2007) conceptualised individual creativity from a developmental perspective in which individuals progress through stages as mini-c where creativity is personally meaningful and new to the creator; little-c stage where the creative act is recognised by other people; pro-C stage where one improves to a point he/she is considered an expert. Finally, the Big-C stage where one is considered a genius and continues to be a legacy for years. Fourthly, the investment theory of creativity was proposed by Sternberg and Lubart (1995). This theory incorporates two approaches to study of creativity that is, person-centred approach and context centred approach. The person centred approach puts more emphasis on the internal aspects of the creative individual. The context centred approach focuses on the interaction of the creative individual with the external context in which one lives. This theory suggests that there are six important resources for creativity which are intellectual capability, knowledge, personality, style of thinking, motivation and contextual situation. Fifthly, Guilford (1967) proposed the structure of intellect model of creativity in which there are two thought processes leading to creativity. These are divergent and convergent thinking. Divergent thinking is the ability to think of as many different possible solutions to an open ended question or problem whereas convergent thinking is choosing which idea or answer is the most worth pursuing. These two thinking processes are sometimes called idea generation and idea evaluation. The concept of divergent thinking is the central concept behind most creativity tests such as Torrance Tests of Creative Thinking (TTCT) (Kaufman & Glaveanu, 2021). The four definitional components of creativity that occur most often in literature are those presented by Guilford (1968). These components that represent divergent thinking are fluency, flexibility, elaboration and originality. The present study progresses in the model of divergent thinking.

1.2. Review of Related Literature

In this section, related literature to creativity and culture, creativity and gender and creativity and grade level are reviewed.

1.2.1. Ethnicity and Creative Thinking

Kim (2009) compared Korean educators' scores on a measure of Confucianism with their scores in a measure of creativity. The results indicated that Confucianism is negatively related to creativity. The elements of Confucianism like unconditional obedience, gender inequality, gender role expectations and suppression of expression present cultural blocks to creativity. Wang and Greenwood (2013) determined Chinese students' perceptions of their own creativity and their perceptions of Western students' creativity. The findings indicated that Chinese students generally perceived their creativity to be less than that of Western students. On the other hand, differences on mini-c and pro-c were larger in the direction of Western students being superior and the items that differed in the opposite direction and those that didn't differ were part of the subset of little-c items. Kyunghwa and Hyejin (2016) investigated cultural differences between Korean and Australian children's' creative characteristics. The findings indicated that Korean's 4th and 5th graders' creative thinking ability was better than Australians'. Tomasscom, Treglia and Tomao (2018) compared creative performance of students in Uganda and Italy. The findings indicated no significant differences between the average total scores of the two groups on creativity and divergent thinking tests. However Ugandan and Italian students had statistically significant differences in flexibility category in favour of Italian students and in fluency in favour of Ugandan students. Smith (2019) compared the creativity scores among African American/ Blacks, Asian American, Hipanic/Latino and white. The findings indicated that African American/Black students had higher mean scores in terms of flexibility, elaboration and originality than Asian American, Hispanic/Latino and whites. On the other hand, the whites had higher mean scores in fluency than the other ethnic groups (African American/Blacks, Asian Americans and Hispanic/Latino). However, these differences were not statistically significant. These studies reveal that the influence of ethnicity or culture on creative thinking is varied between cultures and inconclusive.

1.2.2 Gender and Creative Thinking

Ghayas, Akhter and Adil (2012) carried out a study to investigate the effect of gender on creativity level of students in the university of Sargodha using Abedi Creativity Test(ACT). The findings revealed that there was no significant effect of gender on the total score of creativity. Roue (2011) examined whether the shortage of females in science and engineering is linked to possible gender based differences in school aged children's divergent thinking using the Wallach-Kogan Creativity Test (WKCT). The findings revealed no significant relationship between gender and fluency, flexibility and originality. Sing and Ping (2010) investigated the creativity of Chinese school children using the new electronic version of Wallach-Kogan Creativity Test. The findings revealed different patterns of gender differences in primary and secondary schools. In grade 4-6, boys scored higher than girls marginally in most creativity indices. In grade 7 and 8, girls excelled boys significantly in figural fluency, flexibility, uniqueness and unusualness. In grade 8, girls also scored higher in verbal flexibility. The gender differences were narrowed down again marginally in grade 9. Naderi, Abdullah, Sharir and Mallan (2009) investigated the differences between gender role-identity and creativity of students at Malaysian universities. All the students were given a Khatena-Torrance Creative Perception Inventory Test. The results revealed non significant difference between female and male students' overall creative perception. Kaufman, Baer and Gentile (2004) used consensual assessment technique in which experts judge a products' creativity from the perspective of gender among ethnic groups. Three separate analyses were conducted by 13 experts in which they rated 103 poems, 104 fictional stories and 103 personal narratives written by caucasian, African American, Latino and Asian students. The findings indicated no gender differences on all the three tasks. Cheung and Lau investigated gender differences in creativity scores using Wallach-Kogan Creativity Test from a sample of 2476 4th to 9th graders from 8 primary schools and 4 secondary schools in Hong Kong. Specifically, girls in the junior high grades excelled boys in figural fluency, figural flexibility, figural uniqueness and figural unusualness. Cox (2002) investigated the relationship between creativity and gender among adult community students in Tennesse using Khatena Torrance Creative Perception Inventory (KTCPI). The findings indicated that creativity differed by gender with males having higher mean levels of creativity. Hemdam and Kazem (2019) explored the developmental trajectory of Oman students(506 males and 484 females) from grade 1 to 10 using the Profile of Creative Abilities (PCA) which measures the creative potential of students. The findings indicated that females' creative performance was significantly better than males' in the creativity index score. Abdalla-Alabassi et al. (2022) examined gender differences in divergent thinking using a meta-analysis of mean difference and variation. To test gender differences in means, results from 213 studies were analysed using a three-level approach. The findings indicated that females outperformed males in divergent thinking. The mean effect size varied by country, divergent thinking subscale, type of task, and ability(gifted vs non-gifted). A test of Greater Male Variability Hypothesis (GMVH) by synthesis of 1152 effect sizes from 187 studies confirmed existence of great male variability. These sampled studies on the influence of gender on creativity were not all based on the same tests of creativity and were also unequivocal. Secondly, none of the studies was focussed in the African context. It significant from a research perspective to carry out studies on creativity in such settings to extend knowledge in such contexts.

1.2.3. Grade Level and Creative Thinking

Hemdan and Kazem (2019) carried out a study to investigate the developmental trajectories of creative ability for high achieving students that consisted of 990 students from grades 1 to 10 in Oman. The students completed 2 subtests of the Profile of Creative Abilities (PCA), a measure of creative potential namely drawings and categories. The findings indicated a developmental trend of creativity across the grade levels. Roue (2011) examined whether there was a relationship between grade level and creativity among grade 8 and 11 students of mid-western school of Minnesota using the Wallach-Kogan Creativity Test that measures divergent thinking. The results showed that the 8th grade students had a higher mean originality score than the 11th grade students. On the other hand, the 11th grade students had a higher flexibility score than the 8th grade students but not statistically significant. Claxton, Panells and Rhoads (2005) conducted a longitudinal study to explore the developmental trends in creativity at the 4th, 6th and 9th grade levels using Creativity Assessment Packet (CAP) examiners manual. CAP measures divergent thinking, divergent feeling and parent rating. The findings indicated a slight increase between 4th and 9th grade. The increases between 4th and 6th and 6th and 9th were not significant. No significant changes were found in fluency or flexibility. The only significant changes were a decrease in originality scores between 4th and 6th grades and

an increase in elaboration scores betwee 6th and 9th grades. Charles and Runco (2001) investigated divergent thinking and evaluative skill in the development of creative thinking in elementary school children. Children from 3rd, 4th and 5th grades received divergent thinking tasks and measures of evaluative accuracy. The results indicated that the accuracy of their originality judgements increased significantly with grade and age. There was also a significant peak in divergent thinking of 4th grade children in the raw fluency scores. The studies used different types of instruments and had varied and inconsistent findings.

1.3. The Present Study

Studies on creativity have dominated many parts of the western world due to its significance as a key engineer that facilitates social harmony and sustainable human development. Many studies devoted to creativity have examined the development of creativity from the perspective of culture or ethnicity, gender and grade level with no equivocal results. With the Kenyan government adapting a competency based curriculum in which one of the key competencies is creativity, it is significant to investigate how creativity develops with the ethnic lens, kenya being a multi-ethnic society and the fact that creativity develops within a cultural context going by extant literature. Secondly, it is important to carry out this study from the perspective of gender since gender inclusivity is a factor of consideration in admission of learners in many primary and secondary schools in the Kenya. This would be helpful in determining any influence that gender would exert in the development of creativity. Thirdly, it is significant to know how creativity develops across grade levels so that programs of instruction are tailor made with these differences in mind. The purpose of the study was therefore to investigate how ethnicity, gender and grade levels influence the development of creative thinking in science in coeducational schools in Kenya.

1.4. Research Questions

The study was guided by the following questions:

a. Are there ethnic differences in creative thinking in science among the Luo and Luhya students in coeducational secondary schools?
b. Are there gender differences in creative thinking in science among the Luo and Luhya students in coeducational secondary schools?
c. Are there grade level differences in creative thinking in science among the Luo and Luhya students in coeducational secondary schools?

2. METHODOLOGY

This section of the paper provides a description of the study research design, the respondents, the creativity measure and statistical analyses.

2.1. Research design

The study adopted the cross-sectional survey design. This design was important in determining the developmental characteristic of creativity in students of co-educational secondary schools at different grades (Fraenkel & Wallen, 2008, Gall, Borg & Gall, 2003). This was done without manipulating variables.

2.2. Respondents

The respondents in this study were purposively drawn from two schools in Kakamega County and Siaya County. Kakamega County is dominated by the Luhya ethnic community where as Siaya County is dominated by the Luo ethnic community. Purposive sampling is useful where the characteristics of a population are known or rich in the data intended for the study (Gall et al., 2003). This sampling technique was used to ensure that schools with requisite characteristics (culture, grade level and gender) were part of the study. Since gender imbalances exist in some Kenyan schools, care was taken during sampling to ensure that only schools that were balanced in terms of gender in all the grade levels were included in the study.

Data were therefore collected from grade 9, 10, 11 and 12 students from the two schools to establish changes in creative thinking. There were 198 students from Kakamega county and 165 students from Siaya County representing 54.5% and 45.5% respectively. The same sample had 195 girls and 168 boys representing 53.7% and 46.3% respectively. The sample for the study was therefore 363 students. The ages of grade 9 to 12 ranged from 15 to 20 years giving a mean age of 16.98 years. Table 1 shows the sample size according to ethnicity, gender and grade level.

Table 1. Sample Characteristics by Grade, Gender and Ethnicity

Grade	Gender	Siaya	Kakamega	Total
9	Boys	10	34	44
	Girls	25	26	51
10	Boys	24	20	44
	Girls	28	27	55
11	Boys	19	14	33
	Girls	16	26	42
12	Boys	21	26	47
	Girls	22	25	47
	Total	165	198	363

2.3. Creativity Measure

Creativity was measured using the Students' Science Creativity Questionnaire (SSCQ) which was adapted from Smith (2019). The questionnaire consisted of four dimensions of Guilford's (1968) creative thinking (fluency, flexibility, Elaboration and Originality). Modifications were made on the questionnaire for use to measure creative thinking in science. Each dimension of creative thinking had four items. The students rated the items on a 5-point likert scale with 1 (Never), 2 (Rarely), 3 (Sometimes), 4 (Often) and 5(Always). The instrument was piloted in a co-educational secondary school not participating in the study. Piloting revealed various dimensions had reliabilities as follows: Fluency 0.73, Flexibility 0.78, Elaboration 0.76 and Originality 0.74 and overall reliability of 0.753

Fluency dimension items measured the ability to produce a large quantity of ideas and focusses on an individuals ability to provide quantity over quality. The flexibility dimension measures the ability to change one's thinking or thought processes with ease. The elaboration dimension measures the ability to add or extend the information provided to them. Originality dimension measures the ability to provide a solution or idea that is novel.

2.4. Statistical Analyses

The data collected were analysed using the Statistical Package for Social Sciences (SPSS) version 23. MANOVA was performed to determine the multivariate effect of the indipendent variables (ethnicity, gender and grade level) on the scores of students for creative thinking (fluency, flexibility, elaboration and originality). Differences among groups were assessed by applying a 4 x 2 x 2 (grade x gender x ethnicity) multivariate analysis of variance (MANOVA) with all the creativity domains (fluency, flexibility, elaboration and originality). Univariate tests were done after analysis of multivariate effects. To determine robustness, a preliminary test was done using Box's M test for homogeneity of covariance matrices. The outcome was significant at $P<0.001$. This implied that robustness was not guaranteed. This may have been due to unequal samples sizes from the two counties. In the present circumstances, Pillai's trace criterion was used since it is a more robust statistic for protection against departures from normality and homogeneity of covariance (Tabachnick & Fidel, 2007).

3. RESULTS

The results are presented according the variables of the study in terms of ethnicity, gender and grade level.

3.1. Ethnicity and Creative Thinking

The main effect for the factor of ethnicity on creative thinking in science was relatively higher than the rest (F (4, 344) = 3.629; p = .007; η2= 0.040). Table 2 shows the univariate analysis on the variable of ethnicity.The analysis shows that there was a statistically significant difference in fluency (F (1, 347) = 6.860; p = .009; η2= 0.019) and flexibility (F (1, 347) = 4.350; p= .038; η2= 0.012) in favor of the Luhya students from Kakamega. The Luo students from Siaya county had higher mean scores in elaboration (Siaya M = 12.06, SD = 3.24; Kakamega M = 11.01, SD = 3.01) and originality (Siaya M = 10.04, SD = 3.39; Kakamega M = 9.46, SD = 3.37) than the Luhya students from Kakamega however, not statistically significant.

Table 2. Ethnic Differences in Creative Thinking

Creativity Dimensions	Siaya		Kakamega		*F*(1, 361)	*P*	*eta²*
	M	SD	M	SD			
Fluency	11.46	3.40	12.30	2.72	6.860	0.009*	0.190
Flexibility	11.50	3.15	11.97	2.77	4.350	0.038*	0.012
Elaboration	12.06	3.24	11.01	3.01	0.007	0.932	0.000
Originality	10.04	3.39	9.46	3.37	2.052	0.152	0.006

$p < 0.05$

The interactive effects between ethnicity and grade level (F (12, 1038) = 1.239; p = .251; η2= 0.014) and ethnicity and gender (F (4, 344) = 593; p = .668; η2= 0.007), were not statistically significant.

3.2. Gender and Creative Thinking

The multivariate effect of the factor of gender on creative thinking in science was not significant F (4, 344) = 0.996, p = 0.410, η2= 0.011). Table 3 shows the descriptive statistics and the univariate analyses of the effect of gender on various the creativity domains.The descriptive analysis shows that the boys had higher scores on all the domains of creative thinking in science than girls. Fluency (boys' M = 12.17, SD = 2.89; girls' M = 11.70, SD = 3.22), Flexibility (boys' M = 11.83, SD = 3.10; girls' M = 11.70, SD = 2.82) Elaboration (boys' M = 12.02 SD = 3.42, girls' M = 11.94, SD = 2.84), Originality (boys' M = 9.98, SD = 3.23; girls' M = 9.51, SD = 3.52).

The univariate analyses on the effect of gender on the creative thinking in science were not statistically significant. fluency (F(1, 347) = 1.601; p = .207; η2= 0.005); flexibility (F(1, 347) = 0.899; p = .344; η2= 0.003); elaboration (F(1, 347) = 0.003; p = .959; η2= 0.000); originality (F(1, 347) = 2.656; p = .104; η2= 0.003). The interactive effect of gender and grade level was statistically significant (F(12, 1038) = 3.524; p = 0.000; η2= 0.039).

Table 3. Gender Differences in Creative Thinking

Creativity Dimensions	Boys		Girls		*F*(1, 361)	*P*	*eta²*
	M	SD	M	SD			
Fluency	12.17	2.89	11.70	3.22	1.601	0.207	0.005
Flexibility	11.83	3.10	11.70	2.82	0.899	0.344	0.003
Elaboration	12.02	3.42	11.94	2.84	0.003	0.959	0.000
Originality	9.98	3.23	9.51	3.52	2.656	0.104	0.003

$p > 0.05$

3.3. Grade Level and Creative Thinking

The multivariate effect of the factor of grade on creative thinking in science was statistically significant F (12, 1038) = 2.869, p = .001, η2= 0.032). Table 4 shows the descriptive statistics and the univariate analyses of the effect of grade on various the creativity dimensions. The descriptive statistics show that in the dimension of fluency, grade 12 had the highest mean (M = 12.54 SD = 3.6) where as grade 11 had the lowest mean (M = 11.01 SD = 3.1), in the dimension of flexibility, grade 9 had the highest mean (M = 11.89 SD = 2.5) where as grade 11 had the lowest mean (M = 11.39 SD = 3.1). In the dimension of elaboration, grade 12 had the highest mean (M = 12.81 SD = 3.1) and grade 10 had the lowest mean (M =

11.43 SD = 2.9) . In the dimension of originality, grade 9 had the highest mean (M = 10.15 SD = 3. 5) where as grade 11 had the lowest mean (M = 8.63 SD = 3.3).

Table 4. Grade Related Differences in Creative Thinking

Creativity	Grade 9		Grade 10		Grade 11		Grade 12		*F*	*p*	*eta²*
Dimensions	M	SD	M	SD	M	SD	M	SD	(3,343)		
Fluency	12.44	2.8	11.52	2.5	11.01	3.1	12.54	3.6	4.184	.006*	.035
Flexibility	11.89	2.5	11.87	2.8	11.39	3.1	11.82	3.4	0.276	.843	.002
Elaboration	11.73	3.0	11.43	2.9	11.97	3.2	12.81	3.1	4.182	.006*	.035
Originality	10.15	3.5	9.94	3.0	8.63	3.3	9.96	3.6	3.416	.018*	.029

The univariate analyses on the effect of grade on the creative thinking in science were statistically significant for fluency (F(3, 343) = 4.184; p = .006; η2= 0.035); elaboration(F(3, 343) = 4.182; p = .006; η2= 0.035); and originality (F(3, 343) = 3.416; p = .018; η2= 0.029); However the effect of grade on flexibility was not statistically significant (F(3, 343) = 0.276; p = .843; η2= .002). The interactive effect of gender and grade level was statistically significant (F(12, 1038) = 3.524; p = 0.000; η2= 0.039). However, the interactive effect of ethnicity and grade level was not statistically significant (F(12, 1038) = 1.239; p = 0.251; η2= 0.014).

Post hoc analysis using Tukey for fluency revealed significant differences between grade 9 and 11 in favor of grade 9 and between grade 11 and 12 in favor of grade 12. With regard to elaboration, there were significant grade level differences between grade 10 and 12 in favor of grade 10. With regard to originality, there were significant differences between grade 9 and 11 in favor of grade 9; between grade 10 and 11 in favor of grade 10 and between grade 11 and 12 in favor of grade 12. With regard to flexibility, there were no statistically significant grade level differences.

4. DISCUSSION

The purpose of the study was to investigate the influence of ethnicity, gender and grade level on the development of creative thinking in science among co-educational schools in Kakamega and Siaya counties in Kenya. The findings indicated significant ethnic differences in favor of Luhya students from Kakamega county in the dimensions of fluency and flexibility. In the dimensions of elaboration and originality, there were no statistically significant differences however the Luo students from Siaya had higher mean scores in the two dimensions. There were non-significant gender differences in creative thinking in science and statistically signicant grade level differences in the dimensions of fluency, elaboration and originality.

These findings with regard to ethnicity are in harmony with some studies that documented ethnic differences. For instance, Wang and Greenwood (2013) found ethnic differences in creativity among Chinese and Western students in favor of Western students. Kyunghwa and Hyegin (2016) found that Korean students had better creativity than Australian students. Tommascom, Treglia and Tomao (2018) found statistically significant differences in favor of Italian students for flexibility and originality and significant differences in fluency and elaboration in favor of Uganda students. Khakhurin and Motalleebi (2008) found that Russian and US participants scored higher than Iranian students on the measures of fluency and originality. Smith (2019) reported that African American students had higher mean scores in terms of flexibility, elaboration and originality than the Asian American, Hispanic/Latino and white counterparts. On the other hand the whites had higher mean scores than the other ethnic groups.

It appears that the Luhya students have developed the ability of flexibility to a greater extent than their Luo counterparts in Siaya county. This can be interpreted in two ways with caution. Firstly, it appears that the environmental context made a significant role. Kakamega county has extreme socio-economic challenges being the highest contributor to the national poverty at 4.77% compared to Siaya at 1.87% (Kenya National Bureau of Statistics, 2014). It is worth noting that these socio-economic challenges may require one to think of various ways to resolve problems. In a school situation, the students'inability to

acquire basic personal needs and pay fees due to poverty may cause the student to constantly change their ideation strategy during a flow of thought on how to survive in that situation. Damian and Simonton (as cited in Barbot et al., 2016) opined that experiences of developmental adversity and diversity of experiences might foster unconventional ideas and push people out of the realm of normality. This can in turn influence development of creativity. Still on the environmental context of Kakamega county, the socio-economic problems of the county are likely to condition the young people/students to think of many solutions to problems. The requirement of something more often provides favorable opportunities for evolution of creative and problem solving skills. Mackinnon (as cited in Sarsani, 2011) observed that children from low socio-economic backgrounds are incidentally left on their own to freely explore and ideate on their own. This freedom is liberating on the child and is likely to positively influence their creativity. Goertzel and Goertzel (as cited in Runco, 2014) observed in their study that most creative people had in their childhood experienced adversity in the form of trauma, deprivations, frustrations, conflicts of the kind to pre-dispose one to deliquency. The poverty situation in Kakamega county is likely to engender creative thinking of the young people. Secondly, the cultural context of the two samples could have made a contribution to the observed differences. The Luo community in Siaya county are tightly organised and collectivist in thinking which does not encourage democratic exchange of ideas as opposed to the Luhya in Kakamega county who are loosely organised with fewer social norms that encourages open and democatic exchange of ideas (Ndeda, 2019). The cultural orientation of the Luhya is more likely to develop their creative potential than the Luo.

The finding of this study with regard to gender concurs with other studies that found non-signicant gender differences. For instance Kaufman, Baer and Gentile (2004), Naderi et al. (2009), Roue (2011), Ghayas, Ahkter and Adil (2012). The current study does not concur with other studies that have revealed gender differences in creativity for instance Cox (2002), Cheung and Lau (2010) and Cheung and Lau (2013). The finding of this study was unexpected in an African context where the traditional gender stereotyped thinking still exist and define relationships in informal settings. In this context, the absence of significant gender differences in creative thinking could have been moderated by teachers' influences in the school environments and the pedagogic practices that enhance gender inclusivity. There have been notable campaigns by the state department of education and non-governmental organisations to eliminate gendered practices in institutions of learning and particularly in the classrooms. The significant gender differences and non-significant gender differences could be further indicate that the influence of gender on the development of creativity in science is moderated by an interaction of a confluence of multiple variables in the environment as has been observed by Taylor et al.(2023).

The other finding of this study with regard to grade level has indicated that there were statistically significant grade level differences in different dimensions of creative thinking except in the dimension of flexibility. Post-hoc analysis revealed that there was a drop in creativity from grade 9 to 11 and rise to grade 12 for fluency. For elaboration, there was a drop from grade 9 to 10 and a rise from grade 11 to 12. In the case of originality, there was a drop from grade 9 to 11 and a rise to grade 12. The findings of the current study with regard to grade level concur with other studies that established grade level differences. For instance Claxton et al. (2005),Sing and Ping (2010), Roue (2011), Alacapinar (2013), Hemdan and Kazem (2019).

In the current study which was cross-sectional in nature, the drops were generally observed from grade 9 to 11and a rise to grade 12. Runco (2011) has observed that the ages of slumps and peaks vary depending on measures used to estimate creativity, the domains where creativity is measured and the context of study. Barbot et al. (2016) has also observed that there is asynchronous development of individual resources involved in creative potential. The aspect of asynchronicity could weaken the ability of creative thinking. The drops and the rises in this study can be interpreted with caution in the following ways. Firstly, as Runco (2011) has observed that slumps may be as a result of individuals reaction to his or her environment and experience. In the Kenyan context, students experience adolescent pressure from grade 9 which hightens at grade 10. During this time, the students experience maladaptive behavior due to a temporal gap between socio-emotional development and development of cognitive control (Barbort et al., 2016). The maladaptive behavior could impede the development of resources that are significant for creative thinking. Secondly, due to the maladaptive behavior of grade 10 students, the normative effects of the school environment come into play. The school authorities would exert disciplinary actions to make the learners conform to the school rules and regulations. These restrictions are likely to impede the

manifestation of divergent thinking. Thirdly, as the students move from grade 10 to 12, they are overcoming the pressures associated with adolescence, maladaptive behavior decreases and the effect of teacher control decreases. These environmental changes are likely to engender creative thinking.

The findings of this study have shown ethnic differences in the dimensions of fluency and flexibility; no significant gender differences and grade level differences in fluency, elaboration and originality in creative thinking in science. These findings make a contribution to existing research as alluded to in the discussion above. In terms of pedagogic practice, science teachers could deliberately make learning environments characterised by tasks that are novel, exciting and realistic which allow students some voice and control over their learning (Beghetto and Kaufman, 2014). Such learning environments could require students to generate multiple ideas and encourage students to solve scientific problems. Such learning environments could be made to encourage gender inclusive pedagogic practices and tailor creative learning experiences to grade level of learners. Secondly, the current study has methodological implications. The sample size was small which precludes wide scale generalisations. The cross-sectional design of the study precludes making strong inferences and only allows for cautious interpretations as has been alluded to in the text. In terms of future research, longitudinal studies could be done with multiple methods of data collection to build a more comprehensive picture of the relationships between these variables and creativity thinking in Science. Bigger sample sizes could also be used to allow wide scale generalisations.

5. CONCLUSIONS AND RECOMMENDATIONS

The findings of this study point to the following conclusions: There were ethnic differences in scientific creative thinking with regard to fluency and flexibility. Secondly, There were no gender differences with regard to scientific creative thinking. Thirdly, There were grade level differences with regard to scientific creative thinking.

The findings of this study build on extant literature in the domain of science in the African context and Kenya to be specific with regard to variables of ethnicity, gender and grade level.

The study recommends the following with regard to pedagogic shift and future research: In terms of a pedagogic shift, the ministry of education should consider popularising creative pedagogies through continous professional development to assist in the developmental trajectory of creative thinking in learners. Future research should also focus on other antecedant variables that could be influencing creative thinking in science and domain specific studies in science.

Data Availability Statement. The data for this study is available at https://doi.org/10.528/zenodo.8142612.

Conflicts of Interest. The author declares no competing interests in this study.

Funding. The author declares no external sources of funding.

REFERENCES

Abdalla Alabbasi, A.M., Thompson, T.L., Runco, M.A., Alansari, L.A., & Ayoub, A.E.(2022). Gender differences in creative potential: A meta-analysis of mean differences in variability. *Psychology of Aesthetics, Creativity and the Arts*. Advance online publication. https://doi.org/10.1037/aca000056

Ahmadi, N., & Besancon, M. (2017). Creativity as a stepping stone towards developing other competencies in classrooms: Review. *Education Research International*, 1-9. https://doi.org/10.1155/2017/1357456

Alacapinar, F.G. (2013). Grade level and creativity. *Eurasian Journal of Educational Research, 50*, 247-266.

Amabile, T.M. (1988). A model of creativity and innovation in organizations. *Research in Organizational Behaviour, 10*, 123-167.

Baer, J. & Kaufman, J.C. (2008). Gender differences in creativity. *Journal of Creative Behaviour, 42*(2), 75-105.

Barbot, B., Lubart, T.I., & Besancon, M. (2016). "Peaks, slumps and bumps": Individual differences in the development of creativity in children and adolescents. *New Directions for Child and Adolescent Development, 2016* (151), 33-45. https://doi.org/10.1002/cad.20152

Beghetto, R.A., & Kaufman, J.C. (2007). Toward a broader conception of creativity: A case for "mini-c" creativity. *Psychology of Aesthetics, Creativity and the Arts, 1*, 73-79.

Beghetto, R.A., & Kaufman, J.C. (2014). Classroom contexts for creativity. *High Ability Studies, 25*(1), 53-69. https://do.org/10.1080/13598139.2014.905247

Charles, R.E., & Runco, M.A. (2001). Developmental trends in the evaluative and divergent thinking of children. *Creativity Research Journal, 13*(3-4), 417-437. https://doi.org/10.1207/S15326934CRJ1334_19

Cheung, P.C., & Lau, S. (2010). Gender differences in the creativity of HongKong school children: Comparison by using the new electronic Wallach-Kogan Creativity Tests. *Creativity Research Journal, 22*(2), 194-199. https://doi.org/10.1080/10400419.2010.481522

Cheung, P.C., & Lau, S. (2013). A tale of two generations: Creativity growth and gender differences over a period of education and curriculum reforms. *Creativity Research Journal, 25*(4), 463-471. https://doi.org/10.1080/10400419.2013.843916

Choi, J.N. (2004). Individual and contextual predictors of creative performance: The mediating role of psychological processes. *Creativity Research Journal, 16*(2&3), 187-199. https://doi.org/10.1080/10400419.2004.9651452

Claxton, A.F., Pannells, T.C., & Rhoads, P.A. (2005). Developmental trends in the creativity of School-age children. *Creativity Research Journal, 17*(4), 327-335. https://doi.org/10.1207/s15326934crj1704_4

Cox, B.F. (2002). *Relationship between creativity and self-directed learning among adult community college students* (Doctoral dissertation, University of Tennesse).Tennesse Research and Creative Exchange. https://trace.tennesse.edu/utk_graddiss/2531

Fraenkel, J.R., & Wallen, N.E. (2008). *How to design and evaluate research in education* (7th ed.). McGraw-Hill.

Gall, M.D., Borg, W.R., & Gall, J.P. (2003). *Educational research: An introduction* (7th ed.). Longman, Inc.

Ghayas, S., Akhter, S., & Adil, A. (2012). Impact of gender and subject on the creativity level of high and low achievers. *Journal of Indian Academy of Applied Psychology, 39*(1), 150-156.

Glaveanu, V.P. (2013). Rewriting the language of creativity: The five As framework. *Review of General Psychology, 17*, 68-81.

Guilford, J.P. (1967). *The nature of human intelligence.* McGraw-Hill.

Hemdan, A.H., & Kazem, A.M. (2019). Creativity development of high achieving students.*Creativity Research Journal, 31*(3), 296-308. https://doi.org/10.1080/10400419.2019.1641684

Hong, E., Peng, Y., O' Neil Jr, H.F., Wu, J. (2013). Domain-general and domain-specific creative thinking tests: Effects of gender and item content on test performance. *Journal of Creative Behavior, 47(*2), 89-105. https://doi.org/10.1002/jocb.26

Kaufman, J.C., & Glaveanu, V.P. (2021). An overview of creativity theories. In J.C. Kaufman & R.J. Sternberg (Eds.), *Creativity: An introduction* (pp.17-30). Cambridge University Press.

Kaufman, J.C., Baer, J., & Gentile, C.A. (2004). Differences in gender and ethnicity as measured by ratings of three writing tasks. *Journal of Creative Behavior, 38*(1), 56-69.

Kenya National Bureau of Statistics (2014). *Economic survey 2014*. Kenya National Bureau of Statistics, Nairobi, Kenya.

Khakhurin, A.V. & Motalleebi, S.N.S. (2008). The impact of culture on the creative potential of American, Russian, and Iranian college students. *Creativity Research Journal, 20*(1), 404-411. https://doi.org/10.1080/10400410802391835

Kim, K.H. (2009). Cultural influence on creativity: The relationship between Asian culture (Confucianism) and creativity among Korean educators. *Journal of Creative Behavior*, *43*(2), 73-93.

Kim, K.H. (2011). The Creativity crisis: The decrease in creative thinking scores on the Torrance Tests of Creative Thinking. *Creativity Research Journal, 23*(4), 285-295. https://doi.1080/1040419.2011.627805

Kozlowski, J.S., Chamberlin, S.A., & Mann, E. (2019). Factors that influence mathematical creativity. *The Mathematics Enthusiast, 6* (1), Article 26. https://scholarworks.umt.edu/tme/vol16/iss1/26

Kyungwhwa, L. & Hyejin, Y. (2016). Cross-cultural research on the creativity of elementary school students in Korea and Australia. *Universal Journal of Educational Research, 4*(11), 2618-2626. https://doi.10.13189/ujer.2016.04115

Lee, H., Kim, J., Ryu, Y., & Song, S. (2015). Do people use their implicit theories of creativity as general theories? *Journal of Creative Behaviour, 49*, 77-93. https://doi:10.1002/jocb.55

Ma, H.H. (2009). The Effect size of variables associated with creativity: A meta-analysis. *Creativity Research Journal, 21*(1), 20-42. https://doi:10.1080/104004/0802633400

Naderi, H., Abdullah, R., Aizan, H.T., Sharir, J. & Mallan, V.K. (2009). Gender differences in creative perceptions of undergraduate students. *Journal of Applied Sciences, 9*(1),167-172.

Ndeda, M.A.J. (2019). Population, movement, settlement and the construction of society to the East of Lake Victoria in pre-colonial times: The Western Kenya case. *The East African Review, 52*, 83-108. http://journals.openedition.org/eastafrica/474

Plucker, J.A., Beghetto, R.A., & Dow, G.T. (2004). Why isn't creativity more important to educational psychologist? potentials, pitfalls and future directions in creativity research. *Educational Psychologist, 39*(2), 83-96. https://doi.org/10.1207/s15326985ep3902_1

Rhodes, M. (1961). An Analysis of Creativity. *Phi Delta Kappan, 42* (7), 305-310.

Roue, L.C. (2011). *A study of grade level and gender differences in divergent thinking among 8th and 11th graders in a mid-western school district* (Doctoral dissertation, University of Minnesota). Minnesota.

Runco, M.A. & Jaeger, G.J. (2012). The standard definition of creativity. *Creativity ResearchJournal, 24* (1), 92-96. https://doi.10.1080/10400419.2012.650092

Runco, M.A. (2011). Developmental trends in creative abilities and potentials. In M.A. Runco & S.R. Pritzker (Eds.), *Encyclopaedia of creativity* (Vol. 1, pp. 376-378). Elsevier.

Runco, M.A. (2014). *Creativity theories and themes: Research, development and Practice* (2nd. ed). Elsevier. http://dx.doi.org/10.1016/B978-0-12-410512-6.00002-3

Runco, M.A., Cramond, B., & Pangani, A.R. (2010). Sex differences in creative potential and creative performance. In D. Mc Creary (Ed.), *Handbook of Gender Research in Psychology* (Vol. 2, pp.343-357). Springer.

Sarsani, M.R. (2011). Socio-economic status and performance in creativity tests. In M.A. Runco & S.R. Pritzker (Eds.), *Encyclopaedia of creativity* (2nd ed.) pp. 360-363. Academic Press.

Shaheen, R. (2010). Creativity and education. *Creative Education, 1*(3), 166-169.https://doi.10.4236/ce.2010.13026

Shao, Y., Zang, C., Gu, T., & Yuan, Y. (2019). How does culture shape creativity? A mini-review. *Frontiers in Psychology, 10* (1219), 1-8. https://doi:103389/fpsy.2019.01219

Sing, L. & Ping, C.C. (2010). Developmental trends of creativity: What twists of turn do boys take at different grades? *Creativity Research Journal, 22* (3), 329-336. https://doi.org/10.1080/10400419.2010.503543

Smith, J.E. (2019). *Creative self-efficacy: Students in general education with learning disabilities and with gifts and talents* (Doctoral dissertation, University of Nevada). UNLV Theses, Dissertations, Professional Papers, and Capstones, 3679. https://digitalscholarship.unlv.edu/thesesdissertations/3679

Sternberg, R.J. (2006). The nature of creativity. *Creativity Research Journal, 18*(1), 87-98. https://doi.org/10.1207/s15326934crj1801_10

Sternberg, R.J., & Lubart, T. I. (1995). *Defying the crowd: Cultivating creativity in a culture of conformity.* Free Press.

Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics.* (5th Ed.). Allyn and Bacon.

Taylor, C.L., Said-Metwaly,S., Carmada, A., & Barbot, B. (2023). Gender differences and variability in creative ability: A systematic review and meta-analysis of the greater male variability hypothesis in creativity. *Journal of Personality and Social Psychology*. Advance online publication. https://doi.org/10.1037/pspp0000484

Tomassoni, R., Treglia, E., & Tomao, M. (2018). Creativity across cultures: Comparison between Uganda and Italian students. *Creativity Research Journal, 30*(1), 95-103. https://doi.org/10.1080/10400419.2018.14/1565

Torrance, E.P. (2008). *Torrance tests of creative thinking: Norms-technical manual, verbal forms A and B.* Scholastic Testing Service.

Wang, B., & Greenwood, K.M. (2013). Chinese students' perceptions of their creativity and their perceptions of western students' creativity. *Educational Psychology: An International Journal of Experimental Educational Psychology, 33*(5), 628-643. https://ro.ecu.edu.au/ecuworks2013/807