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Research article

Collective creativity in science classrooms: Scale adaptation and an investigation in terms of demographic variables

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Abstract: Academics and traditional schooling normally focus on achievement in the classroom, and so students' inherent creativity rarely gets explored or expressed. In this study, the psychometric properties of the Turkish version of the Science Classroom Creativity Scale (SCC Scale) were evaluated. The scale has nine factors and a total of 49 items to determine science-specific creativity. A total of 422 students in grades 5–10 in the Central Anatolia Region of Turkey participated in the study. The results showed that the model fit values of the SCC scale are as follows: $\chi 2$ /df = 2.07, RMSEA = 0.05 [90% CI: 0.065; 0.078], S-RMR = 0.05, AGFI = 0.91, NFI = 0.90, IFI = 0.95, GFI = 0.91, CFI = 0.92, TLI = 0.91. Also reliability analyses showed that Cronbach's alpha coefficient ranged between 0.90 and 0.96, while McDonald's omega coefficient ranged between 0.90 and 0.98. The validity evidence also indicated that the scale was appropriate for the Turkish sample. In addition, students' creativity was analyzed in terms of demographic variables. Accordingly, the science-specific creativity level varied according to grade level, but there was no statistical difference according to gender. The results were discussed in terms of student creativity in science classrooms.

Keywords: reliability and validity, questionnaire, science classroom creativity, students

1. Introduction

Collective creativity is linked to systems models that deal with the interaction between the individual and social elements [19]. According to these models, individual factors in creativity interact with social factors, partly shaping them and leading to the emergence of a collective intellectual expression in the group [7]. Vygotsky states that collective creativity is often overlooked because the concept of creativity is linked to an individual achievement or product, but many of humanity's greatest achievements are the product of a collective effort [59]. Participants in the collective learning process can combine ideas, thereby creating entirely new ones together. The result of this process is the possession of collectively shared knowledge as well as collectively derived creative outcomes [8].

Previously, instruments that measured creativity from different perspectives were developed and used in the Turkish sample. Kandemir and Kaufman [28] tried to measure general creativity in university students, while Karakelle and Saraç [31] tried to measure the creative mindset in a large sample of people between the ages of 19 and 41. Sen and Yörük were more interested in ideological views in their undergraduate and graduate samples [50]. Dikici [11] measured teacher behaviors that support creativity. Finally, the components of general creativity [61], individual creativity [62], and creativity in action [30] in young age groups were examined. However, domain-specific creativity skills, such as collective creativity in Turkish high-school science classrooms, have not been addressed. As a result, determining students' creativity in science classrooms may facilitate our understanding of the components necessary to support creativity. On the other hand, since there is no Turkish scale related to science creativity or collective creativity in science classrooms in the literature, there is a need for a scale adaptation. This study is important in filling the gap in the literature and drawing attention to cultural differences. It can be further pointed out that through the adaptation and application of the SCC scale, this study is expected to provide specific guidance and improvement directions for Turkish science education in teaching practice, curriculum design, etc., enhancing the pertinence and practicality of the research purpose.

2. Theoretical background

2.1. Models of creativity

Many researchers have addressed creativity by considering the collective impact of cognitive, emotional, and environmental aspects [47]. This led to the concept of collective creativity for individuals working together [19]. However, collective creativity was mainly addressed in business management [2]. However, Kaufman and Beghetto proposed four levels of creativity: a) *Big-C*, related to eminent accomplishment; b) *Pro-c*, related to professional expertise; c) *little-c*, related to everyday innovation; and d) *mini-c*, related to transformative learning [32]. Accordingly, in a classroom setting, a student's creativity assessed by their peers and teacher was considered little-c, while self-reported creativity was considered mini-c.

Apart from this model, different models of creativity in education also attracted attention. Rhodes proposed the 4P model of creativity to examine creativity more deeply [46]. According to this model, the 4Ps of person, process, product, and press/environment are intertwined. Amabile proposed a model that addresses individual or small-group creativity and organizational innovation through the components of creativity and innovation [2]. This model defines creativity as “the generation of new and useful ideas by an individual or small group” [2].

On the other hand, Woodman and Schoenfeldt addressed creativity with an interactionist model [60]. In this model, cognitive style, personality traits, and social influences were considered to explain creative behavior. They developed an ecological model utilizing this method. In this model, the 4Ps interacted with "creative problem solving". Finally, Puccio et al. proposed the creative change model. In this model, "leadership" was included in the 4Ps model [45]. All of these model proposals created the infrastructure for collective creativity in science classrooms.

2.2. Creativity in science classrooms

Hong and Song tried to explain these factors related to creativity in science classrooms with the science classroom creativity (SCC) model [23]. According to the SCC model, creativity is a collaborative phenomenon developed in the context of teacher and student interaction [4]. This model is notably different from the old understanding of science focused on individual initiative [24]. SCC falls more in line with the modern understanding of science, which recognizes that science is a phenomenon developed in sociocultural collaboration [23]. Therefore, according to SCC, collective creativity can be developed through group interaction in science lessons [56,57].

Accurate assessments are needed to uncover students' creative potential [47]. For the evaluation of creativity in science classrooms, collective creativity remains the focal point [23]. This is because student creativity includes contexts influenced by the teacher and environment in addition to individual creativity [26]. However, related literature has reported that creativity should be assessed in a domain-specific manner [13,48,53]. In particular, scientific creativity is related to thinking styles that are based on scientific knowledge and skills and include different sources of motivation [17,44]. Assessment tools become necessary in the determination of creativity in the classroom. This study aimed to adapt the SCC scale, previously developed by Hong et al [24], into Turkish.

In the previous literature, creativity was mostly evaluated in the context of the individual [2], thus a domain-specific instrument was not developed [42,52]. To the best of our knowledge, the SCC scale is the first instrument to address science-specific collective creativity. Due to this contextual structure, we have decided to adapt the SCC scale for the Turkish sample. Findings from different cultures will become available after future studies incorporate this seminal information into their own research. Detailed information about the SCC scale is presented below.

2.3. Dimensions of the science classroom creativity scale

Hong et al. [24] analyzed the science classroom creativity scale (SCC scale) in nine dimensions based on the SCC model. The characteristics of the dimensions are listed as follows:

i) Student cognitive characteristics: According to Amabile [2], an individual's skills and creativity in a task area are related to their cognitive characteristics. An individual's learning styles or abilities are one of the components of creative behavior. Yin et al. [63] asserted that creativity is related to idea generation and convergent thinking processes. While convergent thinking is related to problem-solving processes, creative idea generation is related to divergent thinking [41].

ii) Student affective characteristics: Intrinsic motivation, innovation motivation, resources in the task area, and innovation-related skills are related to creativity [23]. Students' interest in science subjectsand voluntary participation are the components of creativity [26].

iii) Internal engagement in science class: Students' interest in understanding science lessons, and their ability to set learning goals and make decisions regarding the learning process are associated with creativity [25]. The main indicators of this component are that the student engages in the process of establishing an equation in a science experiment and continues to investigate in the process in depth [29]. In this process, students internalize science and try to integrate science by showing creativity throughout the process.

iv) External engagement in science class: Students collaborating to complete a given task in the science classroom and expressing the results they have obtained has been accepted as another dimension of creativity [24]. Accordingly, actions such as problem-solving in a scientific inquiry, discussing questions with the teacher, and expressing findings of the research are related to this component [23].

v) Science classroom environment: According to McLean [40], creativity is influenced by the classroom environment. Both the physical and sociocultural environment of the classroom is important in collective creativity [17]. Adequate time in the classroom, resources, communication, and task level are components related to the classroom environment [2].

vi) Cognitive support of the science teacher: It is important for the teacher to guide students with appropriate questions, arouse curiosity, offer new ideas, and provide appropriate feedback in terms of cognitive support [36]. Teachers who understand the basic characteristics of creativity can develop it by supporting problem-solving and convergent thinking [53].

vii) Emotional support of the science teacher: The teacher's behaviors such as encouraging students to think positively, showing interest in their questions, and giving positive feedback are effective for students' creativity [51]. Behaviors that console and support students in cases of failure are also important in the development of creativity [13].

viii) Individual creative behavior: Solving the problem individually in a new way, developing new and valuable ideas, and receiving praise from others contribute to individual creativity [24].

ix) Collective creative behavior: Solving new problems collaboratively, generating ideas together, and sharing the results collectively have been accepted as elements of collective creativity [9]. Individuals recognize the value of collective problem-solving in addition to the individual solution of the new idea or the new result obtained [10].

3. The importance of the study

According to the Organization for Economic Co-operation and Development [43], innovation does not happen through individuals who think or work alone, but through those who can communicate and collaborate with others using existing knowledge. This also applies to educational environments [27,51]. Understanding student creativity rather than achievement-oriented creativity in schools is considered particularly important in science education [55] because cognitive, affective, and environmental factors have a collective effect on creativity [23].

Creativity in science classes is explained as the collaborative generation of ideas by individuals who learn together [44]. Therefore, measuring creativity in science classrooms uncovers the potential for creative reflection rather than simply creative productivity [47]. Turkish society already has a collective consciousness [1]. Understanding the collective creativity of this structure in students can be beneficial for cultural studies. For this reason, this study conducted psychometric measurements of a scale that had previously been introduced to the literature, albeit in a different culture.

This study aims to adapt the SCC scale into Turkish and conduct validity and reliability studies. In this context, the scale developed by Hong et al. [24] was adapted into Turkish. In addition, the scores obtained from the SCC scale according to the demographic characteristics of the students were analyzed. In this context, we analyzed the scores obtained from the SCC scale according to gender and grade-level variables.

4. Method

4.1. Participants

The participants of the study consisted of students attending middle and high school in the Central Anatolia Region of Turkey in the 2022–2023 academic year. The convenience sampling technique was used to select the students. A total of 422 students, 255 (60.4%) female and 167 (39.6%) male, participated in the study. The mean age of the students was 13.30 years (SD = 1.86, range = 10–17 years). Of the participants, 29 (6.9%) were in 5th grade, 91 (21.6%) were in 6th grade, 76 (18.0%) were in 7th grade, 15 (3.6%) were in 8th grade, 114 (27.0%) were in 9th grade, and 97 (23.0%) were in 10th grade.

4.2. Instruments

4.1.1. The demographic characteristics form

A form was prepared by the researchers to access demographic information. The form sought information regarding the gender, age, and grade level of the students.

4.1.2. SCC scale

The SCC scale was developed by Hong et al. [24] with a South Korean sample of 7th- to 12th-grade students. The scale consists of student cognitive characteristics (four items), student affective characteristics (five items), internal engagement in science class (five items), external engagement in science class (five items), the science classroom environment (nine items), cognitive support of the science teacher (six items), emotional support of the science teacher (six items), individual creative behavior (four items), and collective creative behavior (five items). The items in the "individual creative behavior" and "collective creative behavior” environment factors are scored on a 5-point frequency Likert scale (1 = never, 2 = hardly ever, 3 = sometimes, 4 = fairly often, 5 = very often). The other factors are scored on a 5-point agreement Likert scale (from 1 = disagree strongly to 5 = agree strongly). Instead of taking the total score of the scale, the dimensions are analyzed at each level. Each dimension is evaluated separately.

4.3. Procedure and data collection

Cross-cultural adaptation of the SCC scale was done by following certain procedural steps [5]. Two bilingual interpreters who are native speakers of Turkish and fluent in English translated the SCC scale into Turkish. One of the translators was an associate professor from the field of measurement and evaluation and the other was an associate professor working in the field of science education. Each of the experts independently translated the SCC scale from English to Turkish. The final Turkish version was generated upon achieving a consensus regarding the language. The back-translation of the SCC scale into Turkish was done by another native English translator. The new English version of the SCC scale was evaluated by another translator and a panel of science education experts and compared with the original version of the scale. The final revisions of the SCC scale were sent to a doctor in the field of Turkish language and asked to examine it in terms of language structure. Then, the Turkish version of the SCC scale was subjected to a pilot study. The form was then provided to 16 students selected from the target sample and the comprehensibility of the form was tested. Thus, linguistic problems and other potential ambiguities were monitored and adjusted for the purpose of clarity.

During the adaptation of the scale into Turkish, the necessary permissions were first obtained from the responsible author of the SCC scale via email. After obtaining the ethics committee and application permission (Necmettin Erbakan University, Ref. No. 15555), the data collection process began. The demographic characteristics form and the document consisting of the SCC scale were delivered to the students through teachers and school principals. In this context, the questionnaire was presented to the students in the classroom. Students completed the questionnaires through a paper-and-pencil test. The questionnaires were distributed during a period of free time at school when students were engaged in leisure activities. Prior to the implementation, a voluntary consent form was presented and students were informed that they could leave the study at any time. It took approximately 30 minutes for the participants to complete the form.

4.4. Data analysis

Before starting the validity and reliability analysis of the SCC scale, missing and incorrect coding in the data set was reviewed. As a result of the application, data was collected from 422 students, but no missing values were detected. SPSS Statistics (ver. 26.0) was used for descriptive statistical analysis.

Before the confirmatory factor analysis (CFA) was applied to the data to examine the construct validity of the scale, unidirectional and multidirectional normality assumptions were tested. First, a one-way normality assumption was tested and skewness and kurtosis values were examined. Since the data was between ± 1.5, it was concluded that the data set was normally distributed [54]. In addition, the Kolmogorov-Smirnov test results ($Z = 1.25$, $p > 0.05$) show that the data conform to a normal distribution. A multivariate normality assumption was tested with the scatter diagram. The data were analyzed in the AMOS program and the maximum likelihood method was adopted. In the evaluation of the fit indices, $\chi^2 / df < 3$, AGFI, GFI, NFI, IFI, CFI, and TLI > 0.90, RMSEA < 0.08, and S-RMR < 0.10 were taken into consideration [33,34].

In the second stage, hypotheses were tested. Levene's test calculated the equality of variances in the scores obtained from the scales. The scores obtained according to the demographic characteristics of the students were analyzed with an independent-sample t-test and one-way ANOVA.

5. Results

5.1. Scale adaptation process

The descriptive statistics test results obtained for the Turkish version of the SCC scale are presented in Table 1. Accordingly, the values obtained mean that the data are typically distributed

(0.119 for skewness and 0.237 for kurtosis). In addition, the mean scores obtained from each factor of the scale are presented.

Table 1. Descriptive statistics of the SCC scale.

Factor	M	M/k	*SD*	Skewness (SE = .119)	Kurtosis (SE = .237)
Student cognitive characteristics	13.61	3.40	2.96	-0.48	0.60
Student affective characteristics	18.22	3.64	4.67	-0.58	-0.17
Internal engagement in science class	17.08	3.41	4.41	-.054	0.07
External engagement in science class	15.70	3.14	4.34	-0.27	-0.25
Science classroom environment	28.45	3.16	6.86	-0.18	-0.06
Cognitive support of the science teacher	20.71	3.45	5.55	-0.57	-0.06
Emotional support of the science teacher	21.09	3.51	5.98	-0.54	0-.20
Individual creative behavior	11.92	2.98	3.61	-0.12	-0.12
Collective creative behavior	14.34	3.58	5.21	-0.11	-0.59

Following the descriptive statistical analyses, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were applied to determine the suitability of the scale for factor analysis. The KMO test resulted in .936, and Bartlett's test of sphericity was significant (χ^2 = 10270.281, d*f* = 1176, $p <$ 0.01). Based on the values obtained, it was decided that the data was factorable [14]. Accordingly, CFA was applied to test the factorial structure of the scale. In the first analysis without any changes, the values obtained for the nine-factor model were as follows: χ^2 (1091) = 2447.656 ($p < 0.01$), χ^2 /d*f* = 2.24, RMSEA = 0.05 [90% CI: 0.063; 0.070], S-RMR = 0.05, AGFI = 0.77, NFI = 0.71, IFI = 0.85, GFI =0 .79, CFI = 0.85, TLI = 0.84. Although these values met the criteria of χ^2 /d*f* < 3, RMSEA < 0.08, and S-RMR <0 .10, AGFI, GFI, NFI, IFI, CFI, and TLI values were not within acceptable limits. Therefore, covariance was drawn between the items provided that they were within the same factor.

Consequently, the error terms between items 16 (I conduct scientific inquiry activities in science classes to solve a problem) and 17 (I often converse with my teacher during science classes) in the external engagement in the science class factor were combined. The error terms between items 38 (My science teacher encourages me to solve difficult problems) and 39 (My science teacher comforts me when I fail to do something) in the emotional support of the science teacher factor and items 45 (My class/group have solved a problem in a new way in science classes) and 46 (My class/group have solved a problem in various ways in science classes) in the collective creative behavior factor were combined. Thus, the model fit values obtained in the final analysis were as follows: χ^2 (1088) = 2254.219 (p <0 .01), χ^2 /d*f* = 2.07, RMSEA = 0.05 [90% CI:0 .065; 0.078], S-RMR = 0.05, AGFI = 0.91, NFI = 0.90, IFI = 0.95, GFI = 0.91, CFI =0 .92, TLI = 0.91. Excellent fit was achieved as a result of these values [33,34].

After examining the factorial structure of the scale, validity and reliability analyses were conducted. The findings obtained from the analyses conducted in this context are presented in Table 2. Reliability analyses showed that Cronbach's alpha (α) coefficient ranged between 0.90 and 0.96, while McDonald's omega (ω) coefficient ranged between 0.90 and 0.98. The reason for examining both in the study pertains to the α coefficient, which is affected by the number of items and is forced to operate with continuous variables [21,39]. In addition, the study continued the analysis by taking factor loadings into account. Therefore, the ω coefficient, which makes allowance for the weighted total load factors, was examined. The *α* and ω coefficients varied depending on the unequal factor loadings. Since the α, ω, and composite reliability (CR) values tested for reliability are above 0.70, we can say that the scale is reliable in the Turkish sample [16,18].

Convergent validity was tested by examining the factor loadings and average variance extracted (AVE) values of the items constituting the scale to determine whether they were above 0.50. Based on the findings, convergent validity was determined to have been provided. Discriminant validity was also ensured as the square root of the AVE values of the factors was greater than the correlation values between the factors. In addition, AVE values were higher than the maximum shared variance (MSV) and average shared variance (ASV) values [18]. Cronbach's alpha is a standard reliability index that measures the internal consistency of a scale. Its value ranges from 0 to 1, where usually 0.70 and above is considered reliable. McDonald's omega is another reliability index used as an alternative to Cronbach's alpha to measure the scale's internal consistency. The omega takes into account more factor structures and can give more accurate results. The value of the omega is between 0 and 1, with 0.70 and above generally considered adequate. CR is an index specifically used to measure the internal consistency of construct scales. CR indicates how reliable the items in each factor are based on the factor structure. Usually, a value of 0.70 or above indicates adequate reliability. AVE is an index that measures how much variance is explained by all variables in a construct. The value of AVE should generally be above 0.50, which indicates that the measured construct elements are sufficiently valid. MSV is the square of the highest correlation in a construct. This indicates how substantial a shared variance is with other factors associated with a factor. The MSV is expected to be smaller than the AVE value. Otherwise, there may be excessive overlap between factors. ASV measures the average of the shared variance in a factor with all other factors. A high ASV value may indicate that factors are highly influenced by each other and difficult to separate. These results indicate that the model had sufficient convergent validity ($CR > 0.70$; $AVE > 0.50$; $CR > AVE$), and discriminant validity ($MSV < AVE$; $ASV < AVE$; correlation between factors $< \sqrt{AVE}$) [15].

Table 2. Factor loading, AVE, CR, MSV, Cronbach's alpha, and McDonald's omega values.

Item number	Factor loading	*α*		*ω*	AVE	√AVE	MSV	AVS	1	2	3	4	5	6	7	8	9
1. Student cognitive characteristics																	
I1	0.823	0.93	0.82	0.97	0.52	0.72	0.31	0.18	-								
I2	0.696																
I3	0.644																
I4	0.727																
2. Student affective characteristics																	
I5	0.672	0.92	0.86	0.97	0.51	0.71	0.50	0.22	0.56**								
I6	0.676																
I7	0.713																
I8	0.722																
I9	0.850																
3. Internal engagement in science class																	
I10	0.681	0.92	0.86	0.97	0.52	0.72	0.50	0.25	0.53**	0.71**	-						
I11	0.706																
I12	0.903																
I13	0.690																
I14	0.639																
4. External engagement in science class																	
I15	0.858	0.91	0.87	0.90	0.55	0.74	0.39	0.23	0.54**	0.60**	0.62**						
I16	0.866																
I17	0.686																
I18	0.748																
I19	0.648																
5. Science classroom environment																	
I20	0.980	0.96	0.95	0.98	0.61	0.78	0.38	0.24	0.38**	0.54**	0.55**	0.63**	-				
I21	0.707																

I22	0.737															
I23	0.690															
I24	0.760															
I25	0.699															
I26	0.939															
I27	0.822															
I28	0.694															
6. Cognitive support of the science teacher																
I29	0.923	0.90	0.90	0.90	0.53	0.72	0.51	0.24	0.42**	0.60**	0.56**	0.52**	0.61**	-		
I30	0.614															
I31	0.645															
I32	0.802															
I33	0.675															
I34	0.733															
7. Emotional support of the science teacher																
I35	0.749	0.90	0.92	0.97	0.53	0.72	0.36	0.22	0.41**	0.54**	0.48**	0.50**	0.60**	0.68**	-	
I36	0.777															
I37	0.706															
I38	0.836															
I39	0.660															
I40	0.815															
8. Individual creative behavior																
I41	0.714	0.91	0.89	0.97	0.53	0.72	0.31	0.15	0.44**	0.40**	0.41**	0.42**	0.53**	0.42**	0.53**	-
I42	0.707															
I43	0.869															
I44	0.952															
9. Collective creative behavior																

I45	0.834	0.91	0.90	0.96	0.55	0.74	0.21	0.18	0.26**	0.28**	0.33**	0.37**	0.45**	0.34**	0.39**	0.56**
I46	0.847															
I47	0.707															
I48	0.740															
I49	0.679															

**Correlation is significant at the 0.01 level.

Table 3. Scores on the SCC scale according to gender.

	Gender	N	Mean	*SD*	*t*	d*f*	*p*
Student cognitive characteristics (Factor-1)	Female	255	13.81	2.86	1.73	420	0.08
	Male	167	13.30	3.08			
Student affective characteristics (Factor-2)	Female	255	18.19	4.64	-0.13	420	0.89
	Male	167	18.25	4.73			
Internal engagement in science class (Factor-3)	Female	255	17.37	4.39	1.69	420	0.09
	Male	167	16.63	4.41			
External engagement in science class (Factor-4)	Female	255	15.68	4.30	-0.15	420	0.87
	Male	167	15.74	4.42			
Science classroom environment (Factor-5)	Female	255	28.66	6.59	0.76	420	0.44
	Male	167	28.14	7.25			
Cognitive support of the science teacher (Factor-6)	Female	255	20.91	5.47	0.36	420	0.36
	Male	167	20.41	5.66			
Emotional support of the science teacher (Factor-7)	Female	255	21.24	5.86	0.53	420	0.53
	Male	167	20.87	6.17			
Individual creative behavior (Factor-8)	Female	255	12.10	3.38	1.26	420	.20
	Male	167	11.65	3.91			
Collective creative behavior (Factor-9)	Female	255	14.40	5.08	0.26	420	0.79
	Male	167	14.26	5.42			

Table 4. Scores on the SCC scale by grade.

		N	Mean	*SD*	d*f*	*F*	*p*	η^2	Difference
Student cognitive	5th grade	29	15.75	2.97		8.83	0.00	0.09	5–6th grade
characteristics	6th grade	91	13.89	3.01	Between Groups: 5				9–10th grade
(Factor-1)	7th grade	76	14.01	2.24	Within Groups: 416				
	8th grade	15	14.00	22					
	9th grade	114	13.74	23					
	10th grade	97	12.18	35					
	Total	422	13.61	29					
Student affective	5th grade	29	21.55	43	Between Groups: 5	9.94	0.00	0.10	9–10th grade
characteristics	6th grade	91	19.42	39	Within Groups: 416				
(Factor-2)	7th grade	76	18.84	41					
	8th grade	15	19.53	49					
	9th grade	114	17.61	44					
	10th grade	97	16.11	50					
	Total	422	18.22	4.67					
Internal engagement in	5th grade	29	18.96	4.47	Between Groups: 5	7.40	0.00	0.08	9–10th grade
science class (Factor-3)	6th grade	91	17.93	4.00	Within Groups: 416				
	7th grade	76	17.98	4.01					
	8th grade	15	18.33	5.40					
	9th grade	114	16.91	4.151					
	10th grade	97	15.02	4.20					
	Total	422	17.08	4.41					
External engagement in	5th grade	29	18.20	4.557	Between Groups: 5	9.40	0.00	0.10	9–10th grade
science class (Factor-4)	6th grade	91	17.15	3.86	Within Groups: 416				
	7th grade	76	16.32	4.31					

	8th grade	15	16.73	4.52					
	9th grade	114	14.91	4.323					
	10th grade	97	13.89	3.84					
	Total	422	15.70	4.34					
Science classroom environment (Factor-5)	5th grade	29	34.13	8.17	Between Groups: 5	8.17	0.00	0.08	5–6th grade
	6th grade	91	29.69	6.78	Within Groups: 416				9–10th grade
	7th grade	76	29.07	7.33					
	8th grade	15	30.60	8.06					
	9th grade	114	26.87	5.13					
	10th grade	97	26.64	6.54					
	Total	422	28.45	6.86					
Cognitive support of the science teacher (Factor-6)	5th grade	29	23.20	5.59	Between Groups: 5	8.17	0.00	0.08	9–10th grade
	6th grade	91	22.28	4.79	Within Groups: 416				
	7th grade	76	22.1	5.12					
	8th grade	15	21.73	7.47					
	9th grade	114	19.40	5.24					
	10th grade	97	18.73	5.61					
	Total	422	20.71	5.55					
Emotional support of the science teacher (Factor-7)	5th grade	29	23.24	6.94	Between Groups: 5	6.71	0.00	0.07	9–10th grade
	6th grade	91	22.30	5.60	Within Groups: 416				
	7th grade	76	22.77	6.21					
	8th grade	15	23.40	7.34					
	9th grade	114	19.91	5.23					
	10th grade	97	19.05	5.62					
	Total	422	21.09	5.98					
Individual creative behavior (Factor-8)	5th grade	29	14.10	3.85	Between Groups: 5	3.62	0.00	0.04	9–10th grade
	6th grade	91	12.41	3.59	Within Groups: 416				
	7th grade	76	12.02	3.74					

	8th grade	15	12.00	2.80						
	9th grade	114	11.50	3.27						
	10th grade	97	11.21	3.67						
	Total	422	11.96	3.61						
Collective creative behavior (Factor-9)	5th grade	29	16.06	5.45		Between Groups: 5	2.30	0.44	-	-
	6th grade	91	15.18	4.94		Within Groups: 416				
	7th grade	76	14.57	5.57						
	8th grade	15	15.13	4.51						
	9th grade	114	13.95	4.92						
	10th grade	97	13.19	5.36						
	Total	422	14.34	5.21						

5.2. Students' SCC levels according to their demographic characteristics

In the study, students' scores on the SCC scale were analyzed according to their gender. According to the results of the independent sample t-test, the creativity scores did not show a significant difference by gender in any dimension of the scale ($t_{factor\ one}(420) = 1.73$, $p = 0.08$; $t_{factor\ two}(420) = -0.13$, $p = 0.89$; $t_{factor\ third}(420) = 0.69$, $p = .09$; $t_{factor\ four}(420) = -0.15$, $p = 0.87$; $t_{factor\ five}(420) = 0.76$, $p = 0.44$; $t_{factor\ six}(420) = 0.90$, $p = 0.36$; $t_{factor\ seven}(420) =0\ .62$, $p = 0.53$; $t_{factor\ eight}(420) = 1.26$, $p = 0.20$; $t_{factor\ nine}(420) = 0.26$, $p = 0.79$).

Second, the scores obtained from the SCC scale were compared according to the grade level of the students in the study. According to the one-way ANOVA results, there was a differentiation between 5th and 6th grades and 9^{th} and 10^{th} grades in the first factor of the scale ($F_{factor\ one}(5416) = 8.83$, $p = 0.00$; $\eta^2 = 0.09$). According to Tukey post-hoc test results, there was also a decrease in the creativity scores in the 6^{th} grade ($M_{grade\ five}= 15.75$, $SD = 2.97$; $M_{grade\ six} = 13.89$, $SD = 3.01$) and the 10^{th} grade ($M_{grade\ nine} = 13.74$, $SD = 2.39$; $M_{grade\ ten} = 12.18$, $SD = 3.50$).

Differentiation in the 2^{nd}, 3^{rd}, 4^{th}, 6^{th}, 7^{th}, and 8^{th} factors of the scale was observed between the 9^{th} and 10^{th} grades ($F_{factor\ two}(5416) = 9.94$, $p =0\ .00$, $\eta^2 = 0.10$; $F_{factor\ three}(5416) = 7.40$, $p = 0.00$, $\eta^2 = 0.08$; $F_{factor\ four}(5416) = 9.40$, $p = 0.00$, $\eta^2 = 0.10$; $F_{factor\ six}(5416) = 8.17$, $p = 0.00$, $\eta^2 = 0.08$; $F_{factor\ seven}(5416) = 6.71$, $p = 0.00$, $\eta^2 = 0.07$; $F_{factor\ eight}(5416) = 3.62$, $p = 0.00$, $\eta^2 =0\ .04$).

This means that the scores on the scale vary according to the grade level. According to this, the creativity score started to decline in the 10^{th} grade ($M_{grade\ nine} = 17.61$, $SD = 4.41$; $M_{grade\ ten} = 16.11$, $SD = 5.02$ for factor two; $M_{grade\ nine} = 16.91$, $SD = 4.15$; $M_{grade\ ten} = 15.02$, $SD = 4.50$ for factor three; $M_{grade\ nine} = 14.91$, $SD = 4.32$; $M_{grade\ ten} = 13.89$, $SD = 3.84$ for factor four; $M_{grade\ nine} = 19.40$, $SD = 5.24$; $M_{grade\ ten} = 18.73$, $SD = 5.61$ for factor six; $M_{grade\ nine} = 19.91$, $SD = 5.23$; $M_{grade\ ten} = 19.05$, $SD = 5.62$ for factor seven; $M_{grade\ nine} = 11.50$, $SD = 3.27$; $M_{grade\ ten} = 11.21$, $SD = 3.57$ for factor eight).

In the 5^{th} factor of the scale, the creativity score again showed a difference between the 5^{th} and 6^{th} grades and the 9^{th} and 10^{th} grades ($F_{factor\ five}(5416) = 8.17$, $p =0\ .00$, $\eta^2 =0\ .08$). Accordingly, students in grades 6 and 10 showed a decrease in their scores on the SCC scale ($M_{grade\ five} = 34.13$, $SD = 8.17$; $M_{grade\ six} = 26.64$, $SD = 6.54$). In the last factor of the scale, no significant difference was found between the classes $F(5416) = 2.30$, $p =0.44$). In all effect size analyses, the values were found to be small ($\eta^2 =0\ .04$ to 0.10) Detailed information on the relevant analyses is presented in Tables 3 and 4.

6. Discussion

In this study, the factor structure, validity, and reliability of the Turkish version of the SCC scale were examined. According to the results, it was determined that the Turkish version of the SCC scale has a nine-factor structure as in the original version. The values obtained regarding the validity and reliability of the scale were similar to the values in the original version. No items were added or removed in the Turkish version of the SCC scale. Based on this, it is possible to say that the validity and reliability analyses and the basic theoretical structure of the SCC scale are also valid for the Turkish version of the scale.

Unlike other instruments that attempt to measure creativity, the SCC scale is the first field-specific instrument that also measures collective creativity in the classroom. Other instruments in the literature tend to be based on the context of school and classroom climate [27,42,52] or partially address the contexts necessary for collective creativity [2,12]. However, it is suggested that the domain-specific nature of science and its collective nature should coexist [23]. In this respect, we can say that the SCC scale is an appropriate tool for assessing creativity in science classrooms in the Turkish sample. It is also crucial that the items in the scale are relevant to Turkish culture. According to Sawyer [49], creativity has shifted from an individualistic perspective to a more collective and sociocultural structure. Because of this, science classroom creativity now involves environmental and contextual factors rather than those simply tailored to eliciting individual creativity [19]. This shows that the social structure is important. Dynamics of Turkish society emphasize collective understanding and recognize the potential of group creativity. This makes the SCC scale particularly appropriate for use in the Turkish sample.

In the study, the data obtained from the SCC scale was examined in terms of demographic variables. According to the analysis, the scores of the students on the SCC scale did not show a statistically significant difference according to their gender. Some studies reported that girls [38] and others reported that boys [22] scored higher in creativity. Still others, as in this study, reported that there is no difference between the scores of male and female students [3]. Therefore, in many creativity studies conducted to date, a clear pattern of gender differences has not yet been reached. There may be different reasons for this. For example, varying results may be due to the nature of the measurement tools used and the construct they attempt to measure. Studies such as the creative school environment [27], creative climate [42], creative classroom environment [52], organizational climate [12], and creative personality [20], which focus on aspects of creativity such as the person, process, or environment, have reported different findings regarding gender.

Furthermore, the theoretical frameworks upon which these measurement tools are based also vary. The components considered in conceptualizing creativity contribute to forming expectations about what exactly the measurement tools are attempting to assess. For example, in Urban's components creativity model [58], which applies the Gestalt approach, personality components were assessed through artistic drawings. In the SCC scale, on the other hand, creativity was associated with the cooperation of individuals, and both classroom environment and teacher effects were included in the study in addition to personal factors [23]. Therefore, the theoretical structure may have led to different results.

He and Wong [22] stated that caution should be taken when comparing averages regarding gender differences in creativity test scores because the average score may be misinterpreted in some cases. In the SCC scale, an average score for the overall scale was not calculated, but the scores obtained from each of the factors were evaluated separately. Therefore, the measurement used and the area of measurement seemed to be important. We understand that more studies using the SCC scale are needed in order to be able to compare the results obtained from the assessment in the field of science. This will produce more information on student creativity in the field of science with regard to gender.

In this study, students' scores on the SCC scale were examined according to their grade levels and it was observed that there was a decrease in the 6th grade (2nd year of transition to middle school) and the 10th grade (2nd year of transition to high school). This finding is quite remarkable because as their levels changed, students achieved higher scores in the first year of the change (5th grade in the first year of middle school and 9th grade in the first year of high school), while their scores decreased in the second year of these levels. According to Lau and Cheung [35], the reason for this is that students are under more pressure as they move up the grades. Younger children are eager to do things like singing or drawing, while older children focus on how others evaluate them. Therefore, creativity decreases as the grade level increases within the education levels [37]. This may be related to the developmental tendency of creativity. According to Besançon et al. [6], creativity is not fixed and can be developed over time through external resources that nurture it.

7. Limitations and implications

Despite the contributions of the study, there are some limitations. First, in the study, which examined the Turkish version of the SCC scale, convergence and discriminant validity techniques were used for validity, and the factor structure was limited only by CFA. A sample of 422 students was used for the CFA, and the results were limited because this sample did not meet the recommended sample size, which should be at least 10 times the number of scale items (49 items). Therefore, the results should be considered in this context. In future studies, cross validity and concurrent validity can be tested differently. In the reliability phase, CR, α, and ω values were examined, but a test-retest was not performed. In addition, the Turkish psychometric structure of the SCC scale was examined based on classical test theory. In further research, studies can be conducted based on latent traits theory.

The sample in the study was selected from only one region of Turkey. Therefore, although the results were confirmed in the Turkish sample, they cannot be generalized to the whole country. In addition, it is possible to obtain different findings from studies conducted in different cultures. In addition, we used convenience sampling as the sampling technique in the study. This may lead to sampling bias.

The study does not mention comparisons of the SCC scale with other external standards or measures to validate its effectiveness in measuring collective creativity in science classrooms further. For example, the scale scores were not correlated with students' creative performance in real science projects or teachers' assessments of students' creativity. This is not within the scope of the study. This omission may weaken the validity of evidence of the scale. To the best of our knowledge, there is no measurement tool other than the SCC scale that measures collective creativity in science. Therefore, similar studies in different cultures and geographies can be conducted to gain insight into student creativity.

The results of this study offer several practical suggestions for fostering creativity in science classrooms. First, the data obtained from the SCC scale revealed that teaching activities should be designed to align with students' individual creativity levels. Accordingly, it is recommended that teacher education programs aim to equip educators with strategies that effectively support creativity.

Moreover, curriculum development processes should emphasize activities that promote creative problem-solving, critical thinking, and scientific inquiry. The SCC scale can serve as a vital tool to measure the effectiveness of these activities and identify areas for improvement. For instance, innovative learning approaches such as project-based learning and group work can help uncover students' creative potential. Additionally, teachers should create a safe and supportive classroom environment to encourage students to express their creative ideas.

In this context, utilizing the SCC scale as a guiding tool for classroom activity design and ensuring teachers have access to training programs that enhance their ability to foster students' creative potential are highly recommended. These steps can support creativity in science education, contributing to students' personal development and future scientific achievements.

8. Conclusions

In this study, the Turkish version of the SCC scale was developed with the participation of 422 middle and high school students. The Turkish version of the SCC scale has a structure consisting of nine factors and 49 items as in the original. The results showed that the Turkish version of the scale had excellent fit and was a valid and reliable measurement tool. Students' scores on the SCC scale according to their demographic characteristics were examined with group comparison analyses and it was noted that there were differences based on grade level. However, no significant difference was found by gender. By looking at this situation from the student development perspective, broader inferences can be made with research from different cultures.

Author contributions

Menşure Alkış Küçükaydın: Conceptualization, Writing – original draft, Writing – review & editing, Analysis, Supervision; Çiğdem Akkanat Avşar: Conceptualization, Writing – review & editing, Supervision. All authors: Formal analysis. All authors have read and approved the final version of the manuscript for publication.

Use of Generative-AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors assert that they do not have any conflicts of interest.

Ethics declaration

This study was approved by the ethics committee of the Necmettin Erbakan University (2023-379).

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