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Specializing the scientific creativity survey for subjects "our foods" and "human and environment" in grade 4 science curriculum

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Abstract

The related literature has included several versions of the scientific creativity survey but lacked its specialized version for grade 4 science curriculum. Therefore, this study aimed to specialize the scientific creativity survey for the subjects "our foods" and "human and environment" in grade 4 science curriculum. After determining the relevant keywords extracted from the scientific creativity literature and previous surveys, we developed subject-specific questions based on them. Later, a group of experts were asked (elementary teacher educators, science educators, elementary school teachers and science teachers) to check the survey's content, applicability and understandability prior to pilot testing with the participants. Then, three successive pilot studies were conducted with different samples to identify its content validity and reliability. The findings showed significant differences for question-total correlation(s), and between the upper and lower groups. Further, its Cronbach's alpha ranged from 0.857 in the first pilot study to 0.907 in the third pilot study. The present study concludes that the specialized scientific creativity survey is valid and reliable for the context (e.g., grade 4 and science course). Thus, it can be used to measure and evaluate grade 4 (aged 10 years) students' scientific creativity and sub-dimensions (e.g., fluency, flexibility, and originality) of the subjects "our foods" and "human and environment."

Keywords: grade 4, scientific creativity, science subjects, survey, science education

INTRODUCTION

Rapid technological advances and the need to keep up with them influence the pre-requests and demands of qualified manpower (Ayu et al., 2020; Dinçer, 2024; Sanabria & Arámburo-Lizárraga, 2016; van Laar et al., 2020). For example, this era has prioritized the 21st century skills for competent citizens and qualified manpower, which include such core subjects as reading and language, world languages, arts, mathematics, economics, science, geography, history, and government and civics. Additionally, they contain life and career skills, learning and innovation skills (critical thinking, communication, collaboration, and creativity), and information, media, and technology skills (Partnership for 21st Century Learning [P21], 2007; Voogt & Roblin, 2012). Of these skills, creativity, which has an innate instinct nature (Aggarwal, 2021; Lowenfeld, 1950), plays a significant role in developing and shaping others (Erol & Erol, 2024; Lai & Viering, 2012; National Research Council [NRC], 2012). For instance, a person with high creativity can easily adapt the 21st century skills into his capabilities or do his best to transform his creative capacity to improve them because he is able to generate novel, diverse, flexible, distinct, and alternative ideas and products to deal with his faced challenges by means of his prior knowledge (Fisher, 2005; Preti & Miotto, 1997). Thus, creativity is seen as a cognitive process and product (Liang, 2002; Torrance, 2018). Given the importance of creativity in scientific procedure and knowledge-in-the making, researchers have strived to

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Contribution to the literature

- Specializing the scientific creativity survey for the subjects "our foods" and "human and environment" in grade 4 science curriculum, this study fills an important gap in the related literature.
- This study provides a valid and reliable survey with subject-specific questions to measure and evaluate grade 4 (aged 10 years) students' scientific creativity.
- This study presents the preliminary findings of grade 4 (aged 10 years) students' subject-specific scientific creativity.

integrate it into learning-teaching processes. Because science, art, literature, mathematics, and engineering have different creativity processes to solve or handle any problem (Sönmez, 1993), subject-specific researchers (e.g., science, technology, engineering, art, and mathematics educators) have preferred using term "scientific creativity" vis-à-vis the one "creativity" (Baer, 2016; Kaufman & Baer, 2009; Liang, 2002; Prahani et al., 2024; Torrance, 2018; Tran et al., 2023). Indeed, this has been a continuous debate about whether it is a general and holistic cognitive feature (Guilford, 1966), or an interaction amongst different types of knowledge, skills, and educational experiences (Gardner, 2009). This means that scientific creativity somewhat differs from creativity in that scientific disciplines (e.g., science, art, and mathematics) prioritize different dimensions (i.e., knowledge, skill, product, process and trait) of creativity (Amabile, 1983, 1996; Baer, 1994; Chen & Chen, 2021; Gardner, 2009; Kaufman & Baer, 2004; Sönmez, 1993).

Since students' knowledge, learning styles, personalities, and motivation levels influence their scientific creativity and learning competencies such as hypothesis formulating, experimental design, and technical innovation to address their encountered challenges (Hu & Adey, 2002; Lin et al., 2003; Samuels & Seymour, 2015), science educators have looked for potential pedagogical strategies to embed scientific creativity within science courses (Prahani et al., 2024). For example, they have proposed some scientific creativity models to better measure and evaluate science learning. That is, Simonton's (2004) scientific creativity model contains sub-dimensions "chance, logic, genius, and Zeitgeist (spirit of the times)," while Jo's (2009) one divides five relevant structures into two groups. The first one incorporates three components (scientific efficacy, creative efficacy, and scientific creativity) that strongly influence each other. The second one includes two components (intrinsic motivation, and content) that are indirectly or weakly related to the first one. The other model proposed by Hu and Adey (2002) covers three main dimensions and nine sub-dimensions: process (thinking and imagining), trait (fluency, flexibility, and originality), and product (technical product, science knowledge, science phenomena, and science problem) (see **Figure 1**). Well-defined framework and interactions make Hu and Adey's (2002) scientific creativity model more discernable, applicable and adaptive for science education than the others (Sarıkaya & Deniş-Çeliker, 2022). Therefore, science educators have generally preferred it to measure and evaluate their students' scientific creativity. Given these arguments, the current study refers to this model for the next stages.

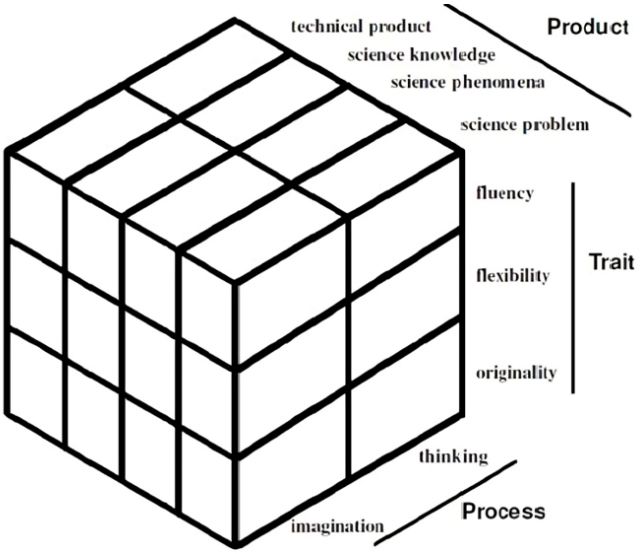

Figure 1. SSCM (Hu & Adey, 2002, p. 391)

Previous Scientific Creativity Instruments

Even though educators have designed and suggested dozens of instruments to measure creative thinking skills (including creativity and scientific creativity) (e.g., Cooper, 1991; Prahani et al., 2024; Torrance & Goff, 1989), this section only outlines scientific creativity instruments in science education, which are of interest in the current paper (see **Table 1**).

As seen from **Table 1**, most of the studies recruited the scientific structure creativity model (SSCM) developed by Hu and Adey (2002) and primarily covered middle and high school students. Also, majority of them measured "trait" dimension of scientific creativity (e.g., fluency, flexibility, and originality). Such general trends in scientific creativity instruments call for a specialized scientific creativity survey for grade 4 students.

The Rationale and Significance

Primary schools play a significant role in developing students' scientific creativity and underlying the next schooling levels (Tomková, 2024).

Table 1. An overview of scientific creative instruments in science education

Study	Instrument name	Underpinned model	n	EL	Sub-scales	Reliability values	Validity values
Atesgoz and Sak (2021)	Test of scientific creativity animations for children	SSCM	8	K-8	Fluency, flexibility, originality, & creativity	Hypothesis formulating: fluency (0.84), flexibility (0.85), originality (0.79), & creativity (0.87) & experiment design: fluency (0.84), flexibility (0.83), originality (0.85), & creativity (0.87)	Hypothesis formulating = 0.862 & experiment design = 0.839
Ayas and Sak (2014)	Creative scientific ability test	SDDS	5	Middle school	Fluency, flexibility, & creativity	0.87	0.31 to 0.59
Bhat and Siddiqui (2017)	Scientific creativity test for senior secondary school students	Unspecified	39	11th & 12th grades	Fluency, flexibility, & originality	Fluency = 0.892, flexibility = 0.82, originality = 0.798, & total reliability = 0.91	Fluency = 0.980, flexibility = 0.468, & originality = 0.832
Chin and Siew (2015)	Figural scientific creativity test	SSCM	6	Pre school	Product (scientific knowledge, scientific phenomena, & scientific problem), process (imagination & thinking), & trait (fluency, originality, elaboration, abstractness of title, & resistance to premature closure)	0.806	0.780 to 0.933
Filiz (2013)	Creativity scale for chemistry classes	Unspecified	7	6th to 12th grade	Fluency, flexibility, & originality	0.836	0.537
Hu and Adey (2002)	Scientific creativity test	SSCM	7	Middle school	Fluency, flexibility, & originality	0.893	0.793 to 0.913
Saenna and Phusee-orn (2022)	Scientific creativity test in science for high school students	Unspecified	8	High school	Originality, flexible thinking, & scientific imagination	Originality = 0.747, flexible thinking = 0.704, & scientific imagination = 0.786	0.60 to 0.80
Siew and Lee (2017)	Scientific creativity test for fifth graders	SSCM	4	5th grade	Technical product, science knowledge, science phenomena, & science problem	Form A = 0.77 & form B = 0.68	Form = 0.528 & form = 0.553
Siew et al. (2014)	Scientific creativity test	SSCM	4	5th grade	Technical product, science knowledge, science phenomena, & science problem	Form A = 0.77 & form B = 0.68	0.99

Note. n: Number of items; EL: Educational level; & SDDS: Scientific Discovery Dual Search Model

As a matter of fact, this role asks science educators for measuring and evaluating primary school students' scientific creativity to properly guide their science learning. Even though scientific creativity acts as a cornerstone to facilitate primary school students' science learning and stimulate their interest in science education (Baysal et al., 2024; Hu & Adey, 2002; Prahani et al., 2024; Liang, 2002; Torrance, 2018), little research has explicitly focused on primary school level (e.g., Atesgoz & Sak, 2021; Cremin et al., 2015; Jongluecha & Worapun, 2022). Also, compared with the studies typically handling common creativity dimensions (e.g., Bhakti & Astuti, 2018; Baysal et al., 2022; Jongluecha & Worapun, 2022; Hernández-Torrano & Ibrayeva, 2020; McCormack, 1971), few science education studies have concentrated on subject-specific scientific dimensions (e.g., Hu & Adey, 2002). These unexplored and missing issues call for the current study to specialize the scientific creativity survey for the subjects "our foods" and "human and environment" in grade 4 science curriculum. Thus, the present study intends to fill an important gap in the related literature by developing a valid, reliable and specialized scientific creativity survey. Further, primary school teachers and science educators could assess grade

Table 2. Relevant keywords for sub-dimensions in the dimension "trait" of scientific creativity

SB	Definitions	Keywords	References
Fluency	• The ability to generate a large number of ideas. • Ability to consider many possible ideas and select the most valuable one(s). • Handles the number of free verbal or non-verbal actions related to ideas. • Prioritizes the quantity rather than the quality of ideas.	Number of ideas	Brown (1989), Edwards (2006), Ersoy and Başer (2009), Hu and Adey (2002), & Torrance (1990)
Flexibility	• The ability to produce ideas that fall into different categories. • Reveals different dimensions. • The ability to think about alternative ways and change his/her ideas. • Suggests different approaches. • The ability to have different perspectives on a subject or event and change them if necessary. • Ability to easily move from one intellectual theme or event to another one.	Creating ideas in different categories	Brown (1989), Edwards (2006), Ersoy and Başer (2009), Hu and Adey (2002), & Torrance (1990)
Originality	• Put forward new and original ideas concerning a subject. • The ability to produce unique and original ideas. • Produces easily unpredictable ideas or products or designs. • Creates or designs a product as a result of his/her invention effort. • Ability to create very different and specific reactions for a subject or event. • Offers unusual or different solutions for a problem.	Original ideas	Brown (1989), Edwards (2006), Ersoy and Başer (2009), Hu and Adey (2002), & Torrance (1990)

Note. SB: Sub-dimensions

Table 3. A summary of learning goals and concepts for the subjects "our foods" and "human and environment" (MoNE, 2018)

Subjects	Learning goals	Concepts
Our foods	Students are able to: F.4.2.1.1 Explain the relationship between life and the ingredients of food. F.4.2.1.2 Make an inference that all foods include water and minerals.	Ingredients of food, water, and minerals
	F.4.2.1.3 Discuss the importance of the freshness and naturalness of foods for a healthy life based on research data.	Food, naturalness, and freshness of food, packaged and frozen foods
	F.4.2.1.4 Associate human health with balanced eating.	Balanced eating, healthy eating, obesity, & food waste
	F.4.2.1.5 Recognize the negative effects of alcohol and smoking on human health. F.4.2.1.6 Take responsibility to get their relatives or people to reduce or give up smoking.	Smoking and alcohol
Human and environment	F.4.6.1 Become conscious consumer. F.4.6.1.1 Pay more attention to economically using resources. F.4.6.1.2 Recognize the importance of recycling and necessary resources for life.	Resource efficiency, saving, frugality, recycling

4 students' scientific creativity via the specialized survey and think about possible intervention studies to improve their scientific creativity levels and qualifications. Also, future research may use this survey to develop strategies and educational policies to stimulate the 21st century skills and increase the qualified manpower (Prahani et al., 2024).

The Aim of the Study

This study aimed to specialize the scientific creativity survey for the subjects "our foods" and "human and environment" in grade 4 science curriculum.

METHODOLOGY

Instrument Development

In developing the survey, we followed the scientific creativity model proposed by Hu and Adey (2002) (see **Figure 1**) and identified relevant keywords for scientific creativity based on a comprehensive literature review (see **Table 2**).

Table 2 points to keywords "number of ideas," "create ideas in different categories" and "original ideas" for "fluency, flexibility, and originality" sub-dimensions, respectively. Also, we examined related science curriculum (see **Table 3**) (e.g., Turkish science curriculum [Ministry of National Education (MoNE), 2018]) to match the learning goals with the keywords prior to writing down questions.

The First Pilot Study: Analysis and Findings

We developed a total of 18 questions given the keywords of scientific creativity (Hu & Adey, 2002), and learning goals of the science curriculum (MoNE, 2018) and sent them to a group of experts (two elementary teacher educators and three science educators), who were familiar with scientific creativity and its measurement-assessment. The experts gave several feedback to better match the questions with learning goals, improve their comprehensibility and tidying up typographical errors (e.g., emphasizing the dominant nutritional elements or ingredients of foods–protein, fat,

carbohydrate). Based on their comments, we carefully revised them.

Sample Used in the Validation

We pilot-tested the survey with 10 students (6 girls and 4 boys), who had already learned the related subjects. Hence, the authors intended to assess its comprehensibility and find unclear or missing points. Further, 12 experts (seven primary school teachers, three science educators, and two science teachers) took part to assess the content validity of the survey.

Data Analysis

The expert marked each question with one of three options (suitable, need revisions, and unsuitable) and depicted their comments as annotated issues. Later, we employed Lawshe (1975) technique to calculate the content validity index, as follows:

$$Content\ validity\ index = \frac{NS}{\frac{N}{2}-1}, \quad (1)$$

where NS is the number of experts who rated the question as "suitable" or "need revisions" and N is the total number of experts, who gave feedback on the question.

Findings of the Validity in the First Pilot Study

The findings of the first pilot study led us to shorten questions and add sample answers for each question that would illustrate the scope. Moreover, in view of Lawshe (1975), the acceptable ratio for the content validity index provided by 12 experts must at least be 0.56. Therefore, we removed questions 2, 3, 6, 7, 10, 12, 13, 15, and 16 from the survey, whose content validity indexes were less than 0.56 (see **Table 4**). That is, after the first pilot study, the survey included nine questions.

The Second Pilot Study: Analysis and Findings

We conducted a routine meeting with the primary school teacher (whose students participated in the first pilot study) to discuss nine questions. She emphasized

Table 4. A summary of the findings of the first pilot study

Q	First versions	CVI	Experts' comments	Revised versions/final decisions
1	Make a list of foods that contain fat. Make sure that your list includes as many foods as possible.	0.84	Needs to be clarified.	Make a list of foods with high fat content. Make sure that your list includes as many foods as you can (for example, hazelnuts).
2	Which of the foods do we eat contain carbohydrates? Try to write down as many foods as possible.	0.50	Overlapped with Q1 and needs to be removed.	Eliminated
3	Make a list of foods that can cause obesity. Make sure that your list includes as many foods as possible.	0.50	Overlapped with Q1	Eliminated
4	Write as many as problem sentences about the concept "saving."	0.84	Good question	No revision on the scaffold of the question but only an example was added: Why should we save money?
5	What could you do to minimize people's needs for a balanced and healthy diet? Please produce as many different ideas as you can.	0.84	Good question	No revision on the scaffold of the question but only an example was added: encouraging people to stop smoking.
6	How can you name the egg differently? Try to suggest many names as possible as you can.	0.33	Out of the scope of curriculum and the current study	Eliminated
7	What are sweet foods? What foods are both sweet and sour? Try to answer as possible as you can.	-0.66	Need to be removed because of the low CVI.	Eliminated
8	Write down as many as possible scientific uses for a grain of wheat.	0.69	Need to use the concept "oil" instead of wheat grain and be clarified.	What kind of scientific purposes can you use oils? Please write down as many as possible scientific uses as you can (For example; soap making).
9	Imagine you are the captain of a ship that has run ashore to an isolated island, which has rivers, fruit trees and a variety of vegetables. What scientific questions about foods would you like to ask? Please write as many questions as you can to help you survive.	1	Good question.	No revision on the scaffold of the question but only an example was added: How can I tell if the water source is clean?
10	Develop a more interesting, useful and innovative recycling bin to make people more aware of its importance.	-0.66	Overlapped with question 18 and need to be removed.	Eliminated

Table 4 (Continued). A summary of the findings of the first pilot study

Q	First versions	CVI	Experts' comments	Revised versions/final decisions
11	What do you think foods would be like if they did not contain water and minerals? Please describe the case.	1	The term "mineral" needs to be removed and clarified.	What do you think foods would be like if they did not contain water? Please write down as many ideas as you can (for example, it would be hard and dry).
12	Imagine that people consume resources unconsciously and prepare a list of possible results. Make sure that your list includes as many results as possible.	-0.66	Overlapped with questions 8-9 and need to be removed.	Eliminated
13	Divide a square cake into four equal parts using as many methods as possible. Please draw it to illustrate your responses.	-1	Out of scope of the current paper and need to be removed.	Eliminated
14	Find as many original solutions as you can to get your relatives or people to reduce or give up smoking.	1	Good question.	No revision
15	You have two kinds of paper towels. How can you test which is better? Please write down as many possible methods as you can and instruments, principles and simple procedure.	-1	Out of scope of the current paper and need to be removed.	Eliminated
16	Write as many problem sentences as possible about the negative effects of alcohol and smoking on human health.	0.50	Overlapped with question 14 and need to be removed.	Eliminated
17	If you had a factory producing packaged yogurt, what would you do to make the packaged yogurt healthier and longer lasting?	1	Need to change its focus to a yogurt machine design by asking students to draw it.	Please design a yogurt making machine and draw it by showing names of each part.
18	How can you make an ordinary yogurt box more innovative, interesting, and useful to save yogurt a longer period. Please draw your ideas.	0.85	Good question	No revision

Note. Q: Question & CVI: Content validity index

that grade 4 students (aged 10 years) would need much more time to respond to the survey that some questions asked them to draw their ideas or solutions or designs. Given the students' profiles and characteristics (e.g., need to have a break and easily boring with writing and drawing tasks), she suggested reducing the number of questions. Likewise, the first author's observations supported her suggestions about the administration of the scientific creativity survey. That is, the students were bored with the questions and tended to leave some questions blank or superficially answer them over time. Given these suggestions, we rechecked the questions with two science educators. The science educators gave feedback on removing the overlapped questions that measure similar sub-dimensions. For example, question 1 (which measures sub-dimensions "fluency, flexibility, and originality") covers question 8 (which focuses on sub-dimensions "fluency and flexibility"). Likewise, even though question 4 and question 9 measure similar dimensions, the students paid more attention to question 9 and casually responded question 4. Given the teacher's and experts' comments, we removed question 4 and question 8 from the survey. Thus, the survey consisted of seven questions for the second pilot study (**Table 5**).

As seen from **Table 5**, nearly all of the questions were designed to measure "fluency, flexibility, and originality" sub-dimensions under the dimension "trait" of the scientific creativity model, while question 5 was developed to evaluate the one "originality." Also,

Table 5. The scope of the survey according to the sub-dimensions of scientific creativity

Questions	Science knowledge	Science phenomena	Science problem	Technical product	Fluency	Flexibility	Originality	Thinking	Imagination
1. Make a list of foods with high fat content. Make sure that your list includes as many foods as you can (for example, hazelnuts).	x				x	x	x	x	
2. Imagine you are the captain of a ship that has run ashore to an isolated island, which has rivers, fruit trees and a variety of vegetables. What scientific questions about foods would you like to ask? Please write as many questions as you can to help you survive (for example, how can I tell if the water source is clean?).			x		x	x	x	x	

Table 5 (Continued). The scope of the survey according to the sub-dimensions of scientific creativity

Questions	Science knowledge	Science phenomena	Science problem	Technical product	Fluency	Flexibility	Originality	Thinking	Imagination
3. What could you do to minimize people's needs for a balanced and healthy diet? Please produce as many different ideas as you can (for example, encouraging people to stop smoking).		x			x	x	x	x	x
4. What do you think foods would be like if they did not contain water? Please write down as many ideas as you can (for example, it would be hard and dry).		x			x	x	x	x	x
5. Please design a yogurt making machine and draw it by showing the names of each part.				x			x	x	x
6. How can you make an ordinary yogurt box more innovative, interesting, and useful to save yogurt for a longer period. Please draw your ideas.				x	x	x	x	x	x
7. Find as many original solutions as you can to get your relatives or people to reduce or give up smoking.	x				x	x	x	x	

question 1 and question 7 were devised to assess the sub-dimension "science knowledge" beneath the dimension "product" and the sub-dimension "thinking" in the dimension "process." Further, question 2 focused on the sub-dimension "science problem" in the dimension "product" and the sub-dimensions "thinking" in the dimension "process" while question 3 and question 4 covered the sub-dimension "science phenomena" in the dimension "product" and the sub-dimensions "thinking" and "imagination" in the dimension "process." Question 5 and question 6 were also planned to unveil the sub-dimension "technical product" in the dimension "product" and the sub-dimensions "thinking and imagination" in the dimension "process." Overall, these seven questions embraced all of the components of scientific creativity (Hu & Adey, 2002).

Sample Used in the Validation

A total of 50 students (29 girls and 21 boys) from the state schools in Yozgat participated in the second pilot study to determine the internal consistency, correlation coefficients, and discrimination values of the survey.

Data Analysis

In analyzing the data, we used the scoring system proposed by Hu and Adey (2002). Questions 1-4, 6, and 7 were totally counted for the sub-dimensions "fluency, flexibility, and originality" whilst question 5 was only calculated for "originality" sub-dimension. That is, we counted all of the students' independent responses regardless of the quality to compute the fluency score. Later, the authors handled the number of different areas or approaches in the students' responses and calculated the flexibility score. Because the originality score depends on variation and uniqueness of their responses, we first tabulated their responses and then scored them with percentage ranges or response probabilities (e.g., smaller than 5%–two points; between 5% and 10%–one point; greater than 10%–zero point). Since question 5 and question 6 looked for particular responses, we rated them in terms of rarity value and exploited a different scoring system for them as suggested by Hu and Adey (2002). That is, when any response was smaller than 5%, we scored it with five points. As any response ranged from 5% to 10%, the authors gave it three points. When it was greater than 10%, the authors computed it with zero point. Afterwards, the authors recruited SPSS 21.0™ to determine the internal consistency, correlation coefficients, and discrimination values of the survey as well as descriptive statistics.

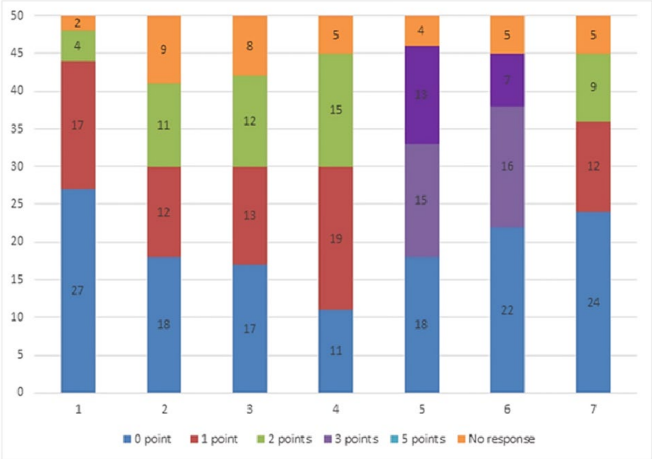

Figure 2. Frequencies of the students' responses in the second pilot study (frequency means number of students' responses with the same score) (Source: Authors' own elaboration)

The Findings of the Second Pilot Study

As seen from **Figure 2**, the majority of the students' responses to questions 1-4 and 7 were either zero or one point. A considerable number of the students' responses to question 5 and question 6 was scored with zero point, whilst a minority of them possessed five points (see **Appendix A** for the students' responses).

Table 6. Correlation coefficients of the question scores (N = 50)

Questions*	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7
Question 1	1						
Question 2	0.773	1					
Question 3	0.739	0.777	1				
Question 4	0.881	0.819	0.806	1			
Question 5	0.801	0.646	0.787	0.879	1		
Question 6	0.818	0.797	0.748	0.786	0.733	1	
Question 7	0.859	0.807	0.825	0.947	0.877	0.799	1

Note. *All the correlations are significant at the 0.01 level (2-tailed)

Table 7. A summary of corrected question-total correlation and Cronbach's alpha

Questions	Corrected question-total correlation	Cronbach's alpha if question deleted (the whole survey = 0.901)
Question 1	0.728	0.907
Question 2	0.662	0.911
Question 3	0.704	0.906
Question 4	0.869	0.896
Question 5	0.691	0.912
Question 6	0.823	0.894
Question 7	0.856	0.890

Table 8. The findings of independent samples t-test for upper and lower groups' scientific creativity scores (N=14 for each of the lower and upper groups)

Questions	Groups	Mean	Standard deviation	df	t	p
Question 1	Upper	1.71	0.91	20.07	3.85	0.001
	Lower	0.64	0.49			
Question 2	Upper	2.71	2.39	14.68	3.02	0.009
	Lower	0.71	0.61			
Question 3	Upper	2.71	1.32	16.58	5.47	0.000
	Lower	0.64	0.49			
Question 4	Upper	2.21	1.36	14.82	3.58	0.003
	Lower	0.85	0.36			
Question 5	Upper	4.00	1.92	15.15	5.61	0.000
	Lower	1.00	0.55			
Question 6	Upper	2.64	1.33	20.36	3.14	0.005
	Lower	1.35	0.74			
Question 7	Upper	2.35	0.49	25.94	7.77	0.000
	Lower	0.92	0.47			

As seen from **Table 6**, correlation coefficients of the question scores ranged from 0.646 to 0.947 and were statistically significant ($p < .001$). Only one correlation coefficient (between question 2 and question 5) had a moderate relationship ($0.30 < \alpha < 70$), while the rest of them exhibited a strong relationship ($0.70 < \alpha$). Cronbach's alpha value for the whole survey was found to be 0.901 for the second pilot study. The values of corrected question-total correlation ranged from 0.662 to 0.869 while those for Cronbach's alpha were between 0.890 and 0.911 if the question was deleted (see **Table 7**).

This means that the survey had a high reliability since all Cronbach's alpha values (see **Table 7**) fell into the reliability range between 0.80 and 1.00 (Büyüköztürk, 2007). All of the questions have contributed to the construct of scientific creativity. Overall, the findings pointed to a significant internal consistency for the survey and addressed that each question individually and collectively measured the same construct.

To examine their discrimination levels, t-value was calculated using the upper and lower 27 percent cases of the sample (Büyüköztürk, 2007; Hu & Adey, 2002). The findings of independent samples t-test showed significant differences between the lower (N = 14) and upper (N = 14) groups ($p < 0.05$) (**Table 8**).

The Third Pilot Study: Analysis and Findings

The third pilot study was carried out with 43 grade 4 students (aged 10 years, 21 girls and 22 boys) drawn from a state primary school in Yozgat. As shown in **Table 9**, the mean values of the total, fluency, flexibility, and originality scores were 15.02, 7.25, 3.06, and 9.06, respectively. Their standard deviations were found to be 9.06, 3.55, 2.54, and 3.98, respectively. Additionally, the kurtosis values were between 0.221 and 0.727 while the skewness ones ranged from -0.845 to 0.307. All of these values fell into the acceptable range between -1 and +1 (Büyüköztürk, 2007).

Table 9. Descriptive statistics of the survey (N = 43)

Scores	Min	Max	Mean	SE	SD	Variance	Skewness	SE	Kurtosis	SE
Scientific creativity total score	1.00	41.00	15.02	1.38	9.06	82.214	0.727	0.361	0.307	0.709
Fluency score	1.00	14.00	7.25	0.54	3.55	12.671	0.221	0.361	-0.845	0.709
Flexibility score	0.00	9.00	3.06	0.38	2.54	6.495	0.697	0.361	-0.435	0.709
Originality score	2.00	18.00	9.06	0.60	3.98	15.876	0.455	0.361	-0.397	0.709

Note. Min: Minimum; Max: Maximum; SE: Standard error; & SD: Standard deviation

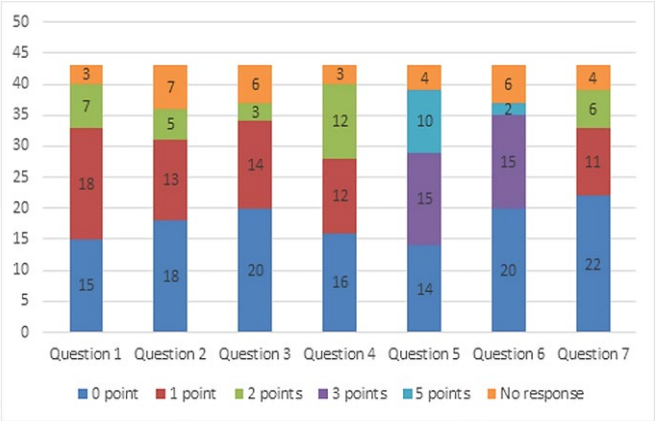

Figure 3. Frequencies of the students' responses in the third pilot-study (frequency means the number of the students' responses with the same score) (Source: Authors' own elaboration)

As can be seen from **Figure 3**, the majority of the students' responses to questions 1-4 and 7 were scored with zero or one point, while there was no response for three points. A remarkable number of their responses to question 5 and question 6 was computed as zero or three points, whereas there were a few responses with five points.

CONCLUSIONS AND IMPLICATIONS

Given the findings of three successive pilot studies, it can be concluded that the specialized scientific creativity survey is valid and reliable to measure grade 4 students' scientific creativity. Because it matched the subjects "our foods" and "human and environment" with the components of SSCM (Hu & Adey, 2002), its content validity is very high and robust to handle related components within these subjects. The findings showed that the students' scientific creativity levels were mostly low or moderate. This calls for future research to improve their scientific creativity levels and diversify their responses or levels. Because this survey with seven questions is time-efficient and economic, researchers and teachers can utilize it to comprehensively evaluate the students' scientific creativity levels and examine any change in scientific creativity over time. Meanwhile, future research may specialize this survey for different subjects, educational levels and contexts.

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APPENDIX A

Table A1. Frequencies, percentages, and originality scores of the students' responses in the second pilot study

Questions	Responses*	f	OS	RR (%)
1. Make a list of foods with high fat content. Make sure that your list includes as many foods as you can (for example, hazelnuts).	Seed	9	0	96
	Walnut	7	0	
	Olive	5	0	
	Sausage	4	1	
	Salam	4	1	
	Milk	4	1	
	Yogurt	3	0	
	Sunflower oil	3	0	
	Salam	2	1	
	Butter	1	1	
	Potato	1	1	
	Meat	1	1	
	Egg	1	2	
	Fish	1	2	
	Tail	1	2	
	Peanut	1	2	
2. Imagine you are the captain of a ship that has run ashore to an isolated island, which has rivers, fruit trees and a variety of vegetables. What scientific questions about foods would you like to ask? Please write as many questions as you can to help you survive (for example, how can I tell if the water source is clean?).	Is the fruit clean?	5	0	82
	Is the water clean?	6	0	
	Is the water poisonous?	4	0	
	Are fruits edible?	3	0	
	Are fruits and vegetables natural?	2	1	
	Are fruits poisonous?	2	1	
	How do I know if fruit is poisonous?	1	1	
	How do vegetables taste?	1	1	
	Are there other living things?	2	1	
	Is the food clean?	2	1	
	How do we know if vegetables and fruits are healthy?	2	1	
	How long will it last?	2	2	
	How do I grow it again if I run out?	2	2	
	How can I pick them to eat?	2	2	
	Is the fruit fresh?	2	2	
	How can we see the germs on the fruit?	1	2	
	How can I tell if the fruit includes pesticide?	1	2	
	How can I tell if the fruit's inside is not rotten?	1	2	
3. What could you do to minimize people's needs for a balanced and healthy diet? Please produce as many different ideas as you can (for example, encouraging people to stop smoking).	Do not consume alcohol	16	0	84
	Healthy eating	7	0	
	Drinking healthy drinks	4	1	
	Do not use drugs	9	0	
	Not smoking a hookah	3	2	
	Eating less	2	1	
	Preferring healthy foods	3	2	
	Avoiding a one-way diet	2	1	
	Getting professional support	2	1	
	Do not eat junk food	3	1	
	Eating fruits	2	2	
	Consuming less salt	1	1	
	Doing sports	3	2	
	Drinking milk	3	2	
	Eating vegetables	3	2	
	Reducing sugar	2	1	
	Dieting	3	2	
	Reducing fat	2	2	
	Avoiding smoking	2	2	
	Do not eat chips	2	2	

Table A1 (Continued). Frequencies, percentages, and originality scores of the students' responses in the second pilot study

Questions	Responses*	f	OS	RR (%)
	A balanced diet	3	2	
	Regularly walking	2	2	
	Dressing for the weather	2	2	
	Do not drink water while sweating	2	2	
	Becoming clean	2	2	
4. What do you think foods would be like if they did not contain water? Please write down as many ideas as you can (for example, it would be hard and dry).	It molds	3	2	90
	It rots quickly	5	1	
	It would be unpleasant	3	2	
	It would be tough	3	2	
	It would not be eaten	3	2	
	We could not make stew	4	1	
	Our teeth would break	3	2	
	There would be no yogurt	6	1	
	It would not be mold	3	2	
	The water content of the body would decrease	3	2	
	There would be no fruit	3	2	
	We could not feed	4	1	
	There would be no vegetables	3	2	
	All food would be the same	3	2	
	We could not cook	3	2	
	Vegetables would not be cooked	2	2	
	Fruits would have no seeds	1	2	
5. Please design a yogurt making machine and draw it by showing the names of each part.	Adding a portion for filling	10	0	92
	Button for the filling part	5	3	
	Strainer in the filling section	4	5	
	Valve for filling	6	3	
	Temperature setting for filling	4	5	
	Indicator for filling	5	3	
	Heating	12	0	
	Adding a temperature control button	5	3	
	Adding a heat indicator	3	5	
	Adding a yeast setting button	5	3	
	Fermentation	5	3	
	Adding a mixer	6	3	
	Adding a storage compartment	5	3	
	Discharge	13	0	
	Adding a button for discharge	5	3	
	Adding a control valve	5	3	
	Adding a packaging part	2	5	
6. How can you make an ordinary yogurt box more innovative, interesting, and useful to save yogurt for a longer period. Please draw your ideas .	Freezing	4	3	90
	Cutting off contact with air	4	3	
	Adding preservatives	2	5	
	Adding a cooler	4	3	
	Adding a heat setting	2	5	
	Becoming suitable for different purposes	3	3	
	Adding oil adjustment	4	3	
	Making glass	3	3	
	Leaving an air gap	2	5	
	Adding a temperature control button	2	5	
	Adding a heat indicator	2	5	
	Making from soil	2	5	
	Adding a fermentation compartment if needed	2	5	
	Emptying compartment	2	5	
	Adding a filter for filling	2	5	
	Adding a slider setting	2	5	
	Adding a cream separator	2	5	
	Adding fat maker from cream	2	5	

Table A1 (Continued). Frequencies, percentages, and originality scores of the students' responses in the second pilot study

Questions	Responses*	f	OS	RR (%)
7. Find as many original solutions as you can to get your relatives or people to reduce or give up smoking.	Banning consumption	4	0	90
	Preparing posters	4	1	
	Preparing brochures	4	1	
	Warning drinkers	4	1	
	Making a movie about its harms	2	2	
	Banning its production	4	1	
	Opening separate places for its sale	4	1	
	Punishing people who do not give up smoking	4	1	
	Adding hot peppers into cigarettes	2	2	
	Do not treat smoking people when they are sick	2	2	
	Establishing rehabilitation institutions	2	2	
	Continuously broadcasting public spot advertisements to encourage people to give it up	2	2	
	Applying pepper to its cotton	2	2	
	Making its taste bad	2	2	
	Using medication to foster them to quit it	2	2	
	Banning smoking at home	2	2	

Note. f: Frequency; OS: Originality scores; RR: Response rate; & *The category "no response" was disregarded to increase the readability of the related table. Because the students were asked to give as many responses as they could, the total number may exceed the total frequency