

Developing a creative personality scale specialized for the topics “buffer solution and salt hydrolysis”

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Abstract

The purpose of this study was to develop a valid and reliable scale to measure high school students' creative personality of the topics “buffer solution and salt hydrolysis.” The draft version of creative personality scale (CPS) consisted of five dimensions (*openness to experience, emotional sensitivity, divergent view, self-resilience, and social adaptability*) with 30 items. A focus group discussion was conducted with five chemistry educators to ensure its content and face validity. Then, it was administered to a total of 331 high school students (aged 16-18 years) to carry out relevant statistical analyses. The confirmatory factor analysis verified five dimensions for 20 items. Also, the findings showed high content and construct (convergent and discriminant) validity, and high reliability. Further, the preliminary findings revealed that majority of high school students had a high creative personality level of the topics under investigation. The current study suggests that the CPS scale could be used to measure student's specialized creative personality.

Keywords: buffer solution, creative personality, creativity, salt hydrolysis, scale development

INTRODUCTION

Scientific and technological developments in the 21st century have underscored the importance of future oriented science education that involve such higher-order thinking skills as creativity, critical thinking, collaboration, communication, and problem solving (Muh.Amin et al., 2026; Erduran et al., 2026; Meda, 2023; Saimon et al., 2023; Trevallion & Nischang, 2021; Ye & Xu, 2023). Thus, they have changed the role of schools from knowledge transmission to skill development to tackle global challenges and meet manpower in future (Diab et al., 2024; Fitriati et al., 2024; Partnership for 21st Century Skills, 2007; Prahani et al., 2026; Rati et al., 2023). Of these skills, creativity not only plays a vital role in helping students generate new ideas and find solutions to various complex problems but also shape other interconnected skills (Beghetto & Kaufman, 2014; Beghetto & Madison, 2022; Güler & Çalık, 2025; Hidayati et al., 2026; Wu & Wu, 2020). Further, its adaptive, and

innovative nature afford them to think about how to face rapid scientific, social and technological changes (Güler & Çalık, 2025). For example, students with high creativity level are able to generate more innovative solutions when they are faced with a problem and confidently partake in discussions to express their ideas (Rahayu et al., 2022; Supena et al., 2021; Wu & Wu, 2020). On the contrary, those with low product creativity tend to become less active in discussions, and have difficulties collaboratively working with one another, and finding innovative solutions to overcome relevant problems (Hidayah et al., 2021; Wu & Wu, 2020). Therefore, school sciences (e.g., chemistry) should cultivate these skills to equip students with them.

Creativity in Chemistry Education

Creativity skills include four dimensions (person, press, process, and product) (Beghetto & Kaufman, 2014; Firestien & Kumiega, 1994; Rhodes, 1961; Sawyer, 2012).

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Contribution to the literature

- This study handles creative personality in the context of the topics “buffer solution and salt hydrolysis” and differentiates it from a general psychological construct.
- This study enriches chemistry education literature through a valid and reliable creative personality scale (CPS) that specializes related chemistry topics with comprehensive psychometric properties.
- This study employs creative personality within five dimensions (openness to experience, emotional sensitivity, divergent thinking, self-resilience, and social adaptability) and provides empirical findings via scale development procedures. It informs chemistry teachers and science educators about how to measure high school students’ specialized creative personality levels by means of the CPS.

Two of them (person and press) refer to internal and external factors affecting students’ creativity, while the rest of them (process and product) describe their learning activities, procedures or experiences in generating ideas, and developing innovative solutions. In this context, a creative student can produce a new product, and/or process, which is different from the existing one (Firestien & Kumiega, 1994; Kaufman & Baer, 2006). Also, their appropriateness, usefulness, or benefits for a specific group may be seen as an indicator of creativity (Sawyer, 2012). Further, since person creativity asks students to use their knowledge and imagination to develop new products (Bresler, 2007), they need to possess a sound understanding of content knowledge (e.g., chemistry concepts) to transform and apply their knowledge and imagination to innovative processes and products (e.g., Mulyopratikno & Wiyarsi, 2025; Nuswowati et al., 2017). Of course, this calls for alternative pedagogical interventions (e.g., problem-based learning, inquiry-based learning, project-based learning, and multiple representation-based instruction) that promote students to improve their creative thinking skills, attitudes and actions (Nuswowati et al., 2017; Nuswowati & Taufiq, 2015; Sumarni & Kadarwati, 2020; Wiyarsi et al., 2018). Hence, students may have a chance to functionally transfer and associate their gained knowledge (e.g., environmental/green chemistry) to their attitudes, skills and actions (Nuswowati et al., 2017). Also, they may perceive a close relationship between creative thinking skills and entrepreneurship abilities. For example, Dewi and Mashami (2019) reported that entrepreneurship-integrated chemistry learning stimulated students’ creative thinking skills (e.g., *originality*, *fluency*, and *flexibility*) and allowed them to re-consider how to transform chemical processes and chemistry knowledge into valuable products.

Furthermore, chemistry learning should provide learning experiences that intertwine conceptual understanding with students’ divergent thinking skills (e.g., creative thinking, analysis, and innovation) to enhance students’ competencies (Tomasevic & Trivic, 2014; Turdubaeva et al., 2025; Veerasinghan et al., 2021). Ismailov (2025) argues that chemistry learning, which enables students to actively build their chemistry understanding, indirectly fosters their divergent

thinking skills (e.g., creative problem-solving). Phrased differently, students’ creativity skills ought to be developed with contextual learning activities or experimental tasks that address real-world problems (Feszterová et al., 2025; Ismailov, 2025; Turdubaeva et al., 2025). For example, Feszterová et al. (2025) used a problem involving the relationship(s) between drinking water safety and chloride level to relate chemistry concepts to everyday life and required the students to design a water purification tool (as a prototype) using simple materials. Feszterová et al. (2025) reported that this process developed the students’ problem-solving skills. Thus, chemistry activities asking students to generate new ideas and solve daily-life problems have the potential to trigger their creativity (Veerasinghan et al., 2021). However, the related literature has reported some challenges (e.g., teachers’ competencies, assessment tools for creativity, and appropriate learning strategies or instructional designs) in developing students’ creativity levels (Tomasevic & Trivic, 2014; Veerasinghan et al., 2021). For example, teachers’ limited conceptions of creativity adversely influence their instructional efforts and preferences for cultivating students’ creativity levels (Tomasevic & Trivic, 2014). Such an inability leads teachers to rely on chemistry textbooks and solely follow learning activities offered by the textbooks. Thus, most of teachers tend to refrain from designing flexible, and creative learning environments. Because teachers rarely use clear measurement criteria or indicators for assessing students’ creativity levels, they do not provide qualified feedback for students’ creativity performances by means of diagnostic, formative and complementary assessment tools (e.g., presentations, projects, and experiments) (Tomasevic & Trivic, 2014). Overall, integrating creativity into chemistry learning facilitates the role of chemistry in developing students’ creative thinking skills and related learning outcomes, and challenges the current learning difficulties.

Students’ Creative Personality in Chemistry Learning

Creativity covers various personal characteristics (e.g., personality, intelligence, and traits—openness to new experiences, ability to understand differences, flexibility in thinking, and resilience for any challenge or

failure) and creative behaviors (e.g., habit, and attitude) (Gough, 1979; Grosul & Feist, 2014; Helson, 1996; Helson et al., 1995; Rhodes, 1961; Selby et al., 2005). This means that creativity is directly related to personal characteristics and creative behaviors. Their interactions appear creative personality, which illuminates how a student responds new experiences, takes risks to generate new ideas from the existing ones, develops alternative ideas, and adapts changing situations (Nuswowati & Taufiq, 2015; Roth et al., 2022). Also, it refers to students' attitudes and resilience towards any failure (Selby et al., 2005).

According to Martinsen (2011), creative personality contains complex interactions amongst students, situations, and cultures. Helson (1996) asserted the following dimensions for creative personality: motivation to fulfil goals (resilience), respect for order and accuracy (tolerance), ability to think about finding discrepancies (critical thinking), imagination, and generating many ideas (divergent thinking ability). According to Helson (1996), creative personality characteristically facilitates creative processes. In view of Gough (1979), creative personality consists of positive and negative dimensions. Zhou (2003) categorized it under three dimensions: resilience, self-confidence, and interest. Based on the foregoing dimensions, creative personality can be summarized beneath five principal dimensions: *openness to experience* (meaning students' openness to new ideas and experiences), *emotional sensitivity* (referring to students' attitudes towards understanding and accepting differing opinions), *divergent thinking* (addressing students' attitudes towards generating various alternative solutions), *self-resilience* (depicting students' resilience in facing difficulties), and *social adaptability* (pointing to students' attitudes towards interacting positively with their social environment) (Gough, 1979; Grosul & Feist, 2014; Helson, 1996; Helson et al., 1995; Selby et al., 2005). This means that teachers and researchers should carefully handle these dimensions to integrate creative personality into school science learning. Hence, creative personality intertwines students' conceptual understanding of science concepts with problem-solving skills and related attitudes/behaviors (Mulyopratikno & Wiyarsi, 2025; Sumarni & Kadarwati, 2020).

Since every student naturally has less or more creativity as a universal human characteristic, his/her creative personality traits can be developed through experience, personal interaction with the environment, and learning contexts (Ordóñez Camacho & Romero Martínez, 2022). For example, students are able to identify the role and types of vehicle fuels, and combustion reactions on hydrocarbon compounds for the topic "petroleum" (Mulyopratikno & Wiyarsi, 2025), and think about alternative fuels, their production processes, and cost-benefit analysis. Thus, understanding the core of the problem (e.g., the impacts

of vehicle fuel combustion and different fuel types), generating many ideas to address the problem (developing alternative fuels from the used motor oil or using plastic wastes for vehicle engines), and selecting about the best solution to address the problem (e.g., considering vehicle engine standards to make a decision about the best alternative fuel) call for the use of creative personalities. Likewise, Sisman et al. (2024) handled the topic "separating mixtures" to identify students' creative personalities and relevant abilities, and expected that students could propose multiple methods (e.g., filtration, decantation, simple distillation, crystallization, the use of magnets, and various combinations) or several ideas for separating a mixture (e.g., preferred alternative patterns--water and oil, or sand and salt). Thereby, offering extreme ideas (e.g., using household items for a simple distillation setup or assembling a condenser setup from a pot, a hose, and ice cubes) could be seen as an indicator of creative personality. Of course, integrating creative personality in chemistry learning needs a specific measurement tool to objectively assess the quality of related learning outcomes.

Chemistry topics may appear various creative personalities (Roth et al., 2022) in that they need different pedagogical approaches or treatments (e.g., Çalik et al., 2023, 2024, 2026; Çalik & Kurt, 2025; Sivrikaya et al., 2026). For example, the topics "buffer solution and salt hydrolysis" may be taught via problem-based learning, inquiry-based learning, or context-based learning (Kargopoulos et al., 2026; Rahmawati et al., 2022; Ratman et al., 2026; Seçken & Alşan, 2011; Sesen & Tarhan, 2011). Further, these topics engage students in understanding related abstract concepts and transferring their gained conceptions to daily-life issues (e.g., regulating blood pH, formulating pharmaceutical products, exploring the effect of overuse of fertilizers on soil quality, and re-thinking how to treat water contaminated by detergent waste). In this process, students should explore various alternative solutions, consider diverse perspectives, discuss their ideas with their peers, and persevere to find possible solutions despite any difficulty. In brief, the interplay(s) between the nature of these topics and five dimensions of creative personality directed the authors to select them to specialize the CPS for chemistry education and measure topic-specific creative personality.

Rationale and Significance of the Study

Few studies have used scales/tests to measure students' personal creativity (e.g., Aziz and Günther, 2023; Ramly et al., 2022; Roth et al., 2022). For instance, Aziz and Günther (2023), who developed CPS for junior and senior high school students, reported Cronbach's alpha (CA) value for the scale to be 0.898. Even though its construct validity somewhat met the model fit, they suggested that the scale is a valuable tool for researchers,

Table 1. Synthesized dimensions in regard to previous theoretical frameworks of creative personality

Dimensions of creative personality					Synthesized dimensions
Selby et al. (2005)	Helson et al. (1995)	Helson (1996)	Welsh (1975)	Grosul and Feist (2014)	
Openness and courage to explore ideas	-	Complexity	Origence	Openness to experience	Openness to experience
Listening to one's inner voice	The resources to engage in symbolic constructions	Externalization			Emotional sensitivity
-	-	Adaptive	Intellectence	Psychoticism	Divergent view
-	Identity that integrates the individual within a sustaining environment	Norm adherence	-	-	Social adaptability
-	Motivation	-	-	-	Self-resilience

educators, and practitioners to better understand and promote creativity in secondary school students. Likewise, Roth et al. (2022), who devised cognitive process oriented creativity scale to measure biology students' creativity levels, stated that their personality dimensions (e.g., conscientiousness, openness to new experiences, agreeableness, extraversion, and neuroticism) were significantly correlated. They offered that further research is needed to assess the extent to which creative cognitive processes are related to other positive outcomes of the school experience. Similarly, Ramly et al. (2022), who constructed chemistry scientific creativity test (CSCT) based on relevant literature (e.g., scientific creativity structure model, Torrance tests of creative thinking, and aspects of scientific creativity), found that the test possessed a high validity and reliability. They suggested that the CSCT could be used to evaluate pre-university students' chemistry-based scientific creativity. Although related literature has included several common scales or tests to measure students' creativity or scientific creativity levels, the nature of creativity calls for a specialized instrument instead of a common one. As a matter of fact, earlier studies emphasized this need to measure students' creative personality in chemistry classes (Keiner et al., 2020; Tomasevic & Trivic, 2014). For example, creativity may be tailored for any educational level (i.e., high school), discipline (i.e., chemistry) or topic (e.g., buffer solution and salt hydrolysis). The current study considers all of them to develop a CPS specialized for the topics of "buffer solution and salt hydrolysis" in high school chemistry curriculum.

Because students confront with abstract chemistry concepts in high school, they should have conceptual understanding and creative thinking skills to apply their chemistry knowledge to daily-life problems (Yadiroğlu et al., 2021). For instance, while learning the topics "buffer solution and salt hydrolysis," they need to recruit their own creative personality to think about innovative solutions, generate alternative ideas/solutions, adapt proper problem-solving strategies, become open to new ideas, and challenge any difficulty (resilience) (Gocłowska et al., 2019). Thus, it is

hypothesized that a specialized scale may provide more insights about high school students' creative personality levels of the topics "buffer solution and salt hydrolysis." To sum up, this study aimed to develop a valid and reliable scale to measure high school students' creative personality of these topics and analyze their creative personality levels via preliminary findings.

METHODOLOGY

Instrument Development

This study followed the instrument development guidelines proposed by relevant literature (e.g., Çalik & Coll, 2012; Coll et al., 2002; Trochim, 2001; Wiyarsi & Çalik, 2019). Given previous theoretical frameworks on creative personality (Welsh, 1975; Helson et al., 1995; Helson, 1996; Selby et al., 2005; Grosul & Feist, 2014), the authors firstly identified relevant dimensions and then classified them based on their conceptual similarities and finally named them with the most common terminologies (see Table 1). For example, the dimensions "openness and courage to explore ideas (Selby et al., 2005), complexity (Helson, 1996), origence (Welsh, 1975), and openness to experience (Grosul & Feist, 2014)" emphasize students' openness to new ideas and experiences. Therefore, the authors merged them under the dimension "**openness to experience**." Because the dimensions "listening to one's inner voice, resources to engage in symbolic constructions, and externalization" refer to students' attitudes and eagerness to understand and accept different ideas, the authors combined them beneath the one "**emotional sensitivity**." Likewise, those "adaptive, intelligence, and psychoticism" deal with students' various alternative solutions. Thus, the authors generated the dimension "**divergent view**" to reflect them. Since those "identity that integrates the individual within a sustaining environment and norm adherence" ask students to positively interact with their social environments, the authors constituted the one "**social adaptability**." Finally, because the dimension "motivation" stresses students' resilience in facing difficulties, they created the one "**self-resilience**." In brief, the authors determined the key features for each

Table 2. Key features of creative personality for each dimension

Dimensions	Key features	IN
Openness to experience (OTE)	Openness to new knowledge Interesting in different ideas	1-6
Emotional sensitivity (ES)	Accepting diversities and differences Becoming tolerant of diverse perspectives	7-12
Divergent view (DV)	Focusing on different perspectives about any problem Finding various solutions after clearly understanding the problem	13-18
Self-resilience (SR)	The ability to adapt and recover any adversity Persevering to follow any task despite any failure or challenge	19-24
Social adaptability (SA)	Reflecting individual traits in a social environment Strengthening the interaction(s) between people and environment	25-30

Note. IN: Item numbers for the draft CPS

dimension of creative personality based on related literature and used them to develop relevant items (see [Table 2](#)).

Also, the authors specialized the items for the topics “buffer solution and salt hydrolysis” in high school chemistry curriculum. The draft version of the CPS (see [Appendix A](#) and [Appendix B](#)) consisted of 30 five-point Likert-type items (from strongly agree to strongly disagree; 6 items for each dimension). Later, the authors invited a group of experts (five chemistry educators held PhD degree, and published papers on the topics “buffer solution and salt hydrolysis, and creative personality”) to check content and face validity. In this process, they conducted a focus group discussion to evaluate how the items matched or mismatched with the dimensions and key features of creative personality and used their feedback to revise the items. Namely, the authors clarified any unclear item and tidied up typographical errors. For the next step, two of the authors, who are bilingual, translated the draft version of the CPS from English to *Bahasa Indonesia* and re-translated to English to identify any meaning missing. Further, they invited five bilingual teachers (three English teachers and two *Bahasa Indonesia* teachers holding master’s degree of education) to review the draft version of the CPS in terms of grammar, writing, and wording issues, and examine its readability, clarity, and comprehensibility. In a similar vein, they asked 24 high school students to read the items aloud and explain their ideas about their meanings, readability and practicality. Thus, this process gave some insights about its content and face validity. After revising and improving the items, the authors administered it to a large sample and followed confirmatory factor analysis to assess its construct (convergent and discriminant validity) and reliability. The next sections present these processes and findings.

Sample Used in the Validation

After obtaining the ethical approval from Yogyakarta State University, the first author contacted the principals of the high schools around Special Region of Yogyakarta, Indonesia. Seven of them (five from downtown and two from rural regions) positively responded and gave the

official permission to collect data. The sample of the study consisted of 331 high school students (aged 16-18 years; 164 in 11th grade and 167 in 12th grade), who followed the science track and were volunteer to respond to the CPS.

The Context of the Study

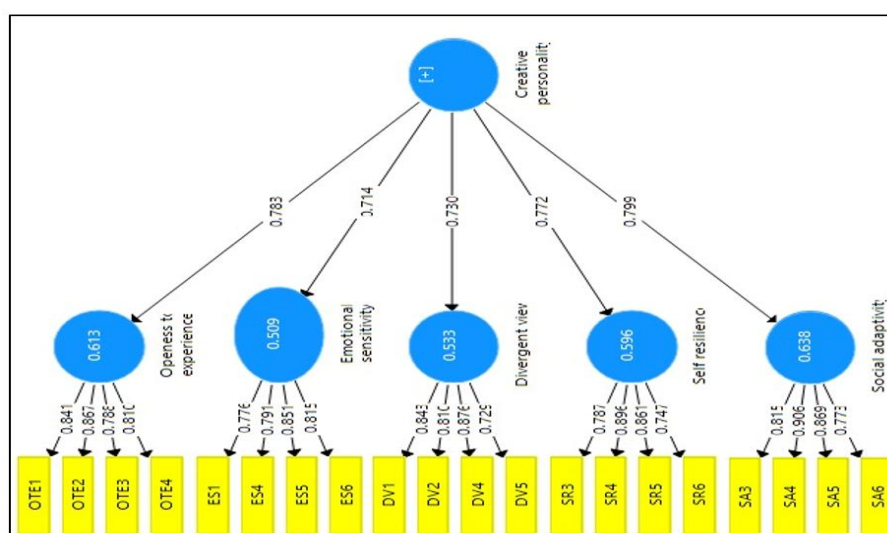
Indonesian educational system divides high school curriculum into two levels. The first level (named phase E) embraces general subjects and intends to identify students’ interests, talents, and career aspirations at 10th grade. The second one (called phase F), which focuses on 11th and 12th grades, offers advanced subjects for students to deepen their interests, talents, and career aspirations. Consequently, the second level contains much more specialized class hours for subjects than the first one. For example, 10th grade students attend an integrated science course for 3 class hours per week, whereas 11th and 12th grade students take such separate science courses as biology, chemistry, and physics. For example, chemistry courses in 11th and 12th grades involve 5 class hours a week. Furthermore, based on the curriculum policy, the topics (e.g., salt hydrolysis and buffer solution) may be flexibly taught at 11th or 12th grades. That is, chemistry teachers should consider schools’ facilities and needs, and students’ characteristics for making decisions about the sequence of chemistry topics.

Data Analysis Procedure

The students responded to the draft version of the CPS about one class hour (45 minutes). The scale included positive (1-5) (items 1, 2, 4, 7, 8, 10, 13, 14, 16, 19, 22, 23, 25, 28, and 29 – A sub-total = 15 items) and negative (5-1) scoring (items 3, 5, 6, 9, 11, 12, 15, 17, 18, 20, 21, 24, 26, 27, and 30 – A sub-total = 15 items) to maintain clarity and avoid any social desirability, bias or ambiguous interpretation (Trochim, 2001). The authors imported the data into SmartPLS4TM to assess convergent validity through factor loading, and discriminant validity along with average variance extracted (AVE), Fornell-Larcker criterion and cross-loading analysis (Wiyarsi & Çalık, 2019). Also, they

Table 3. Standardized factor loadings for the final version of the CPS

Codes	Item number	Divergent view (DV)	Emotional sensitivity (ES)	Openness to experience (OTE)	Self-resilience (SR)	Social adaptability (SA)
DV1	9	0.843				
DV2	10	0.810				
DV4	11	0.876				
DV5	12	0.729				
ES1	5		0.776			
ES4	6		0.791			
ES5	7		0.851			
ES6	8		0.815			
OTE1	1			0.841		
OTE2	2			0.867		
OTE3	3			0.788		
OTE4	4			0.810		
SA3	17					0.815
SA4	18					0.906
SA5	19					0.869
SA6	20					0.773
SR3	13				0.787	
SR4	14				0.896	
SR5	15				0.861	
SR6	16				0.747	

**Figure 1.** The model fit for the CPS according to the findings of CFA (OTE: Openness to experience, ES: Emotional sensitivity, DV: Divergent view, SR: Self-resilience, SA: Social adaptability) (the authors' own elaboration)

analyzed reliability via rho A and composite reliability (CR) by means of IBM SPSS Statistics 25™. Meanwhile, they employed the following criteria to interpret the preliminary findings in regard to mean (M) scores (Miller et al., 2008): very low ($M \leq 2.00$), low ($2.00 < M \leq 2.67$), fair ($2.67 < M \leq 3.33$), high ($3.33 < M \leq 4.00$), very high ($M > 4.00$).

RESULTS AND DISCUSSION

Convergent and Discriminant Validity

As seen from Table 3, the findings of the CFA indicated that the standardized factor loadings of 20 items ranged from 0.729 to 0.906, which are higher than

the acceptable threshold (0.70) offered by Hair et al. (2014, 2019), and Wiyarsi and Çalık (2019). Ten items (items 5, 6, 8, 9, 15, 18-20, 25, and 26) were removed from the model because of their low standardized factor loadings. The findings of the CFA (Figure 1) confirmed the model fit with five-dimensions for the final version of the CPS and pointed to high convergent validity.

Discriminant validity was evaluated via cross-loading analysis, AVE, and Fornell-Larcker criterion. Of these analyses, the AVE gives some insights about discriminant and convergent validity and generates a basis for the Fornell-Larcker criterion and cross-loading analysis (Farooqi & Naeem, 2023; Hair et al., 2019; Kohli et al., 2025).

Table 4. AVE and reliability indices for the CPS with five dimensions

IN	DC	AVE	CA	Rho A	CR
9	DV1	0.666	0.832	0.842	0.888
10	DV2				
11	DV4				
12	DV5				
5	ES1	0.654	0.824	0.827	0.883
6	ES4				
7	ES5				
8	ES6				
1	OTE1	0.684	0.846	0.849	0.896
2	OTE2				
3	OTE3				
4	OTE4				
17	SA3	0.680	0.856	0.856	0.894
18	SA4				
19	SA5				
20	SA6				
13	SR3	0.709	0.878	0.878	0.907
14	SR4				
15	SR5				
16	SR6				

Note. IN: Item numbers & DC: Dimension codes

As can be seen from **Table 4**, the findings of the AVE were between 0.654 and 0.709, which are higher than the acceptable value (0.50). This means that each dimension explained more than half of the related variance.

After the findings of the AVE, the Fornell-Larcker criterion was also applied for discriminant validity. As seen from **Table 5**, there were high correlations between the dimensions. This means that each dimension had a greater variance than others (Carter, 2016; Jamshidimanesh & Mohammadkhani, 2024; Jiang et al., 2023; Rönkkö & Cho, 2022).

In a similar vein, the findings of cross-loading analysis (see **Table 6**) revealed that every item had its highest loading for the targeted dimension. This means that all of the items served to their planned dimensions and distinguished their intended dimensions from others (Farooqi & Naeem, 2023; Kohli et al., 2025).

Overall, the findings revealed high discriminant validity for five dimensions and relevant items (see **Appendix A** and **Appendix B** for the final version of the CPS).

Table 5. The findings of discriminant validity in regard to the Fornell-Larcker criterion

Dimensions	Divergent view (DV)	Emotional sensitivity (ES)	Openness to experience (OTE)	Self-resilience (SR)	Social adaptability (SA)
Divergent view (DV)	0.816				
Emotional sensitivity (ES)	0.309	0.809			
Openness to experience (OTE)	0.477	0.545	0.827		
Self-resilience (SR)	0.512	0.416	0.460	0.825	
Social adaptability (SA)	0.493	0.485	0.483	0.533	0.842

Table 6. The findings of cross-loading matrix for the final version of the CPS

Codes	Item number	Divergent view (DV)	Emotional sensitivity (ES)	Openness to experience (OTE)	Self-resilience (SR)	Social adaptability (SA)
DV1	9	0.843	0.275	0.429	0.437	0.376
DV2	10	0.810	0.214	0.441	0.391	0.426
DV4	11	0.876	0.310	0.434	0.446	0.438
DV5	12	0.729	0.197	0.225	0.399	0.369
ES1	5	0.268	0.776	0.583	0.278	0.397
ES4	6	0.235	0.791	0.416	0.352	0.367
ES5	7	0.270	0.851	0.420	0.398	0.459
ES6	8	0.219	0.815	0.328	0.313	0.333
OTE1	1	0.438	0.365	0.841	0.364	0.381
OTE2	2	0.456	0.461	0.867	0.418	0.435
OTE3	3	0.349	0.416	0.788	0.367	0.378
OTE4	4	0.330	0.557	0.810	0.372	0.402
SA3	17	0.227	0.512	0.286	0.329	0.815
SA4	18	0.499	0.419	0.489	0.526	0.906
SA5	19	0.546	0.371	0.484	0.504	0.869
SA6	20	0.339	0.348	0.334	0.408	0.773
SR3	13	0.422	0.318	0.279	0.787	0.383
SR4	14	0.478	0.360	0.467	0.896	0.453
SR5	15	0.427	0.395	0.463	0.861	0.499
SR6	16	0.356	0.289	0.277	0.747	0.417

Table 7. Descriptive statistics of the students' creative personality for each item and dimension

Dimensions	Item number*	M	Standard deviation	Category
Openness to experience (OTE)	1	3.755	0.913	High
	2	3.843	0.838	
	3	3.870	0.793	
	4	4.063	0.831	Very high
	Sub-total	3.883	0.690	High
Emotional sensitivity (ES)	5 (7)	4.190	0.862	Very high
	6 (10)	3.925	1.017	High
	7 (11)	4.027	0.967	Very high
	8 (12)	3.949	1.033	High
	Sub-total	4.023	0.785	Very high
Divergent view (DV)	9 (13)	3.414	0.902	High
	10 (14)	3.405	0.940	
	11 (16)	3.396	0.939	
	12 (17)	3.106	0.978	Fair
	Sub-total	3.330	0.766	Fair
Self-resilience (SR)	13 (21)	3.202	0.904	Fair
	14 (22)	3.577	0.964	High
	15 (23)	3.722	0.964	
	16 (24)	3.465	1.102	
	Sub-total	3.492	0.809	High
Social adaptability (SA)	17 (27)	4.363	0.967	Very high
	18 (28)	3.719	0.974	High
	19 (29)	3.471	0.985	
	20 (30)	3.517	1.019	
	Sub-total	3.767	0.810	High

Note. *Different item numbers for the draft version of the CPS were presented in parenthesis

Preliminary Findings of the Students' Creative Personality Levels

The preliminary study showed that the students' mean scores of the creative personality fell into "high" category. Furthermore, sub-dimensions were classified under various categories. For instance, high category contained dimensions "openness to experience ($M = 3.883$), self-resilience ($M = 3.492$), and social adaptability ($M = 3.767$)," whilst fair category included the one "divergent view" ($M = 3.330$). Also, the dimension "emotional sensitivity ($M = 4.023$)" was labelled beneath very high category (see [Table 7](#)). The students' creative personality levels indicated that they were generally open and innovative to solve related problems for the topics "buffer solution and salt hydrolysis" (Pavlić et al., 2023). Further, they tended to have a strong emotional sensitivity about diversity and differences, and respect their friends' opinions or suggestions. This may result from the traits of sensitive people such as high prosocial behavior, and better engagement with creative activities (Bas et al., 2021; Bridges & Schendan, 2019; Laros-van Gorkom et al., 2025; Trnka, 2023).

The "fair" category for the dimension "divergent view" may come from the students' limited understanding of the topics "buffer solution and salt hydrolysis" or their limited ability to associate these topics with daily-life problems (Sanjiwani et al., 2020; Laliyo et al., 2022). This category indicates that the students seem to have had some deficiencies at

generating multiple alternative solutions or handling a problem in terms of multiple perspectives (scientific, environmental, social, and cultural) (Grosul & Feist, 2014; Welsh, 1975). For example, the lowest mean score for item 12 (*I often have difficulty determining solutions for any buffer solution problem*) (see [Table 7](#)) supports this argument. Likewise, the students' regular learning habits (e.g., teacher-centered learning, and solving clear-cut or algorithmic problems) may have affected their abilities to solve complex problems with many alternative solutions (de Vink et al., 2022; Wood, 2006). Since the dimension "divergent view" has a crucial role at improving and strengthening students' personal creativity levels, open-ended problem-solving activities (e.g., STEM education, project-based learning, problem-based learning, inquiry-based learning, and reflective discussions) should be integrated into lesson plans or sequences as pedagogical strategies to foster their divergent thinking skills of the topics under investigation (Banks & Barlex, 2014; Pinar et al., 2025; Pozuelo-Muñoz et al., 2023; Smith et al., 2022).

The "very high" category in the dimension "emotional sensitivity" (see [Table 7](#)) means that the students could recognize and respect to different ideas and manage their emotions while solving topic-related problems. Also, these findings indicated that they tend to be open mind for their peers' feedback and consider various solutions to solve the problems (Helson, 1996; Helson et al., 1995; Selby et al., 2005). This may be seen

as an indicator of the students' social and emotional readiness levels to partake in cooperative/collaborative learning activities that encourage them to communicate, discuss, and cooperate with each other (Ma et al., 2025; S. E. Tan & Jung, 2024). Thus, such activities fostering positive and reflective interactions (e.g., listening, respecting and responding to peers' feedback, comments, critics or ideas) support their emotional sensitivity and creativity levels (Frانيا & Correia, 2022; Garaigordobil et al., 2022; H. Wang et al., 2024; Shi et al., 2025). Meanwhile, even though mean scores of items in this dimension were somewhat different, they fell into the "high and very high" categories (see Table 7). For example, item 5 (*I can accept my friends' different opinions to solve buffer solution-related problems*) had the highest mean score for this dimension, while item 6 (*I am not easily offended even though my friends reject my suggested idea or solution regarding any salt hydrolysis problem*) possessed the lowest one (see Table 7). These findings revealed that the students could generally become tolerant of diverse perspectives or ideas instead of an excessive emotional response or action. Indeed, such a crucial characteristic/habit explicitly fosters creativity in that creative processes ask students to evaluate, revise, and refine any idea through their peers' feedback or comments (Garaigordobil et al., 2022; Huang et al., 2024; Mänty et al., 2020).

As seen from Table 7, item 17 (*I have no respect for my friends' ideas about daily life salt hydrolysis problems*) in the dimension "social adaptability," which was exposed to a negative scoring, had the highest mean score ($M = 4.3625$, very high category). This means that the students seem to have highly valued their peers' ideas while discussing the relevant problems. In addition, this may stem from the nature of the Indonesian education system, which fosters students to develop excellent interpersonal skills and respect for their peers during social interactions and discussions (Supriatna et al., 2024; Wiyarsi et al., 2024). Such a dialogic learning environment, which promotes students to re-consider their ideas, evaluate their conceptions, and develop more innovative solutions, facilitates the development of creativity and creative personality (Carmeli et al., 2015; Pillay et al., 2020).

Furthermore, the highest mean score ($M = 4.063$, very high category) in the dimension "openness to experience" was belonging to item 4 (*I am enthusiastic about my friends' ideas for solving salt hydrolysis problems*). This means that the students tend to be interested in their peers' ideas and handle different perspectives/ideas to extend or accommodate their understanding of the related problems. In fact, such a socially situated learning environment has the power to cultivate creativity and creative personality through peer-to-peer dialogues, and collaborations (Çalık & Ebenezer, 2018; Chen et al., 2022; C. S. Tan et al., 2019; X. Wang et al., 2025). Similarly, item 15 (*I insist on solving salt hydrolysis*

problems even if they are very difficult) in the dimension "self-resilience" possessed the highest mean score ($M = 3.722$, high category). This indicates that the students tend to persevere to follow any task despite any failure or challenge for the relevant problems. However, the mean score of item 13 (*I have difficulty finding any alternative solution as my proposed solution fails for any salt hydrolysis problem*) falls into the "fair" category (see Table 7). This means that the students' self-resilience levels and related abilities should be strengthened to adapt and recover any adversity in problem-solving processes (Helson et al., 1995). Hence, such a learning habit/attitude (e.g., persisting in generating alternative ideas, and testing, revising, and refining them to find the most effective solution for the related problem) triggers their creativity and creative personality levels (Anderson & Graham, 2021; Leroy & Romero, 2022; Lucas & Nordgren, 2015).

To sum up, the "high and very high" categories in the items (see Table 7) may be approved as the indicators of the students' high curiosity and strong willingness to explore any impact, source, and reason of the topics "buffer solution and salt hydrolysis" and associate them with daily-life problems. In fact, these characteristics (e.g., having a high curiosity) may stimulate creative alternative solutions and keep students open to new experiences and ideas while thinking about daily-life problems about the topics under investigation and evaluating problem-solving processes (Banks & Barlex, 2014). Such a dialogic learning environment not only allows them to explore new ideas and think about different alternatives, but also explicitly supports their creative personality levels (Taylor Bunce & Boerger, 2022). Moreover, the "fair" category for items 12 and 13 (see Table 7) may come from their limited ability to suggest effective solutions for daily-life problems using the topics "buffer solution and salt hydrolysis" and their prior experiences of failure challenging self-resilience. Thus, they seem to have needed to learn how their failed experiences shape their chemistry/science learning. Phrased differently, drawing upon their own failures and errors to generate innovative, new or alternative ideas supports a sustainable creative personality for chemistry/science learning (Smith & Henriksen, 2016).

CONCLUSION AND IMPLICATIONS

The findings showed that the final version of the CPS consisted of 20 items under five dimensions. Given the findings, it can be concluded that the CPS appears to have high content, and construct (convergent, and discriminant) validity. Further, the findings of the reliability indicators (AVE, CR, and CA) ensured a high reliability to measure the students' creative personality levels. Based on these findings, it can be deduced that the CPS is a valid and reliable instrument to measure and assess students' creative personality levels. Also, it may be adapted into other chemistry topics or different

disciplines to specialize students' creative personality and assess their levels within science learning contexts. In a similar vein, further research should be undertaken to explore its generalizability for various educational systems, cultures and school types. Given the preliminary findings, it can be inferred that the students' creative personality levels are relatively high but need to be cultivated with well-designed chemistry activities. Such a need calls for intervention studies supporting their learning capabilities to generate creative ideas and find alternative solutions for scientific problems. Thus, future research should focus on how to develop students' creative personality levels. Additionally, a follow-up research may employ the preliminary findings of the current study to design qualitative data collection tools (e.g., interview) and qualitatively investigate the reasons for students' creative personality levels in depth.

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APPENDIX A: ENGLISH VERSION OF THE CREATIVE PERSONALITY SCALE (CPS)**Name:****Class:****Day/date:****Instructions**

1. Read and consider each question carefully before selecting an answer.
2. Select one answer for each statement by checking (✓) the answer column.
3. Be honest and do not be influenced by your friends' answers.

No	Items	Responses				
		SA	A	U	D	SD
1	I am interested in identifying the causes and effects of any problem using the concept "buffer solution" in chemistry.					
2	I am motivated in analyzing the causes and effects of any problem using the concept "salt hydrolysis" in chemistry.					
3	I have little interest in determining the causes and effects of any problem using the concept "buffer solution" in chemistry.					
4	I am enthusiastic about my friends' ideas to solve salt hydrolysis problems.					
5	I am a little enthusiastic about my friends' ideas to solve buffer solution problems.					
6	I show relatively little interest in my friends' ideas for solving salt hydrolysis problems.					
7	I can accept my friends' different opinions to solve buffer solution-related problems.					
8	I am open to my friends suggested ideas to solve any salt hydrolysis problem in daily life.					
9	I am often reluctant to accept my friends' opinions on how to work out any buffer solution problem.					
10	I am not easily offended even though my friends reject my suggested idea/solution about any salt hydrolysis problem.					
11	I am offended if my friends reject my suggested idea/solution about any buffer solution problem.					
12	I feel hurt unless my friends accept my offered ideas concerning salt hydrolysis problems.					
13	I can analyze various issues in daily life relating to the concept of buffer solutions in any perspective (cultural, environmental, social and scientific).					
14	I can come up with alternative ideas using the concept "salt hydrolysis" to solve daily life problems.					
15	I can analyze various issues in daily life relating to the concept of buffer solutions only use scientific perspective.					
16	I can find solutions for any salt hydrolysis problem.					
17	I often have difficulty determining solutions for any buffer solution problem.					
18	I often struggle to identify appropriate solutions for salt hydrolysis problems.					
19	I can find alternative solutions when my suggested solution does not work for any buffer solution problem.					
20	I cannot look for any alternative solution when my suggested solution does not work for any buffer solution problem.					
21	I have difficulty finding any alternative solution as my offered solution fail for any salt hydrolysis problem.					
22	I persevere to solve buffer solution problems even if they are so difficult.					
23	I insist on solving salt hydrolysis problems even if they are so difficult.					
24	I easily become discouraged while solving difficult buffer solution problems.					
25	I behave politely and respectful to my friends, even though I have different ideas about any buffer solution problem.					
26	I clearly express my own ideas regarding any buffer solution problem, even though they may offend my friends.					
27	I have no respect for my friends' ideas about daily life salt hydrolysis problems.					
28	I try to produce creative and beneficial ideas for my school or local communities to overcome any buffer solution problem.					
29	I can develop innovative solutions that have positive environmental impacts to overcome salt hydrolysis problems.					
30	I rarely think about the impact of my ideas on solving buffer solution problems in my local community.					

Note. SA: Strongly agree; A: Agree; U: Undecided; D: Disagree; SD: Strongly disagree; & Items in red were removed from the item pool after related analysis

APPENDIX B: INDONESIAN VERSION OF THE CREATIVE PERSONALITY SCALE (CPS)

Nama:

Kelas:

Hari/tanggal:

Petunjuk pengisian

1. Bacalah dan pertimbangkan setiap pertanyaan dengan cermat sebelum memilih jawaban.
2. Pilihlah satu jawaban untuk setiap pernyataan dengan mencentang (✓) kolom jawaban.
3. Jujurlah dan jangan terpengaruh oleh jawaban teman-temanmu.

No	Butir pernyataan	Respon saya				
		SS	S	R	TS	STS
1	Saya tertarik untuk mengidentifikasi penyebab dan dampak suatu masalah menggunakan konsep larutan penyangga dalam kimia.					
2	Saya termotivasi untuk menganalisis penyebab dan dampak suatu masalah menggunakan konsep hidrolisis garam dalam kimia.					
3	Saya kurang tertarik untuk menentukan penyebab dan dampak suatu masalah menggunakan konsep larutan penyangga dalam kimia.					
4	Saya antusias dengan ide teman-teman saya untuk menyelesaikan masalah hidrolisis garam.					
5	Saya kurang antusias dengan ide teman-teman saya untuk menyelesaikan masalah larutan penyangga.					
6	Saya menunjukkan antusiasme yang terbatas terhadap ide-ide teman-teman saya untuk menyelesaikan masalah hidrolisis garam.					
7	Saya dapat menerima pendapat lain dari teman saya untuk menyelesaikan masalah yang berkaitan dengan larutan penyangga.					
8	Saya terbuka terhadap ide-ide yang diajukan oleh teman-teman saya untuk menyelesaikan masalah hidrolisis garam dalam kehidupan sehari-hari.					
9	Saya kesulitan menerima pendapat teman saya tentang cara menyelesaikan masalah larutan penyangga.					
10	Saya tidak mudah tersinggung meskipun teman-teman saya menolak ide yang saya berikan untuk menyelesaikan masalah hidrolisis garam.					
11	Saya merasa tersinggung jika teman-teman saya menolak ide saya untuk menyelesaikan masalah larutan penyangga.					
12	Saya cenderung merasa sakit hati jika teman-teman saya tidak menerima ide-ide saya untuk mengatasi masalah hidrolisis garam.					
13	Saya dapat menganalisis berbagai masalah dalam kehidupan sehari-hari yang berkaitan dengan konsep larutan penyangga menggunakan berbagai perspektif (budaya, lingkungan, sosial dan sains).					
14	Saya dapat menghasilkan ide-ide alternatif menggunakan konsep hidrolisis garam untuk menyelesaikan masalah dalam kehidupan sehari-hari.					
15	Saya dapat menganalisis berbagai masalah dalam kehidupan sehari-hari yang berkaitan dengan konsep larutan penyangga hanya menggunakan perspektif sains.					
16	Saya dapat menemukan solusi untuk masalah hidrolisis garam.					
17	Saya sering kesulitan menentukan solusi untuk masalah larutan penyangga.					
18	Saya sering kesulitan mengidentifikasi solusi yang tepat untuk masalah hidrolisis garam.					
19	Saya dapat menemukan solusi lain untuk menyelesaikan masalah larutan penyangga ketika solusi yang saya berikan tidak berhasil.					
20	Saya berhenti mencari solusi lain untuk menyelesaikan masalah larutan penyangga ketika solusi yang saya berikan tidak berhasil.					
21	Saya kesulitan menemukan solusi lain untuk mengatasi masalah hidrolisis garam setelah solusi awal saya gagal.					
22	Saya tetap berkomitmen untuk menyelesaikan masalah larutan penyangga meskipun tingkat kesulitannya tinggi.					
23	Saya akan terus berusaha menyelesaikan masalah terkait hidrolisis garam, meskipun sulit.					
24	Saya cepat merasa putus asa saat menyelesaikan masalah larutan penyangga yang sulit.					
25	Saya tetap sopan dan menghormati orang lain, meskipun saya memiliki pandangan berbeda tentang cara menangani larutan penyangga.					
26	Saya tetap mengemukakan pendapat saya tentang cara menyelesaikan masalah larutan penyangga dengan cara saya sendiri, meskipun hal itu mungkin menyinggung orang lain.					
27	Saya tidak menghormati ide teman saya dalam menyelesaikan masalah hidrolisis garam dalam kehidupan sehari-hari.					
28	Saya berusaha mengembangkan ide kreatif untuk mengatasi masalah larutan penyangga yang bermanfaat bagi lingkungan sekitar.					
29	Saya mengembangkan solusi inovatif untuk mengatasi masalah hidrolisis garam dengan dampak positif bagi lingkungan.					
30	Saya jarang memikirkan dampak ide saya dalam mengatasi masalah larutan penyangga di lingkungan sekitar.					

Catatan. SS: Sangat setuju; S: Setuju; R: Ragu-ragu; TS: Tidak setuju; STS: Sangat tidak setuju; & Item-item ini telah di hapus dari kumpulan item setelah dilakukan analisis terkait