



Chemistry Identity Profiles Across Entry Cohorts Among Prospective Chemistry Teachers: Implications for Quality Education

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Abstract: Chemistry identity shapes students' engagement and persistence in learning chemistry. This study profiled chemistry identity among Chemistry Education students, examined differences across entry cohorts, and tested gender differences in chemistry identity. A quantitative cross-sectional survey was conducted with 176 students from the Chemistry Education Study Program at Universitas Tanjungpura using the 20-item Measure of Chemistry Identity (MoChI) on a 5-point Likert scale (overall reliability $\alpha = 0.91$). Overall chemistry identity did not differ significantly across cohorts ($p = .755$), and no significant cohort differences were found in any MoChI subconstruct. Descriptively, value-related interest was the strongest component ($M = 4.21$ – 4.48), whereas feeling-related interest was the next strongest ($M = 3.72$ – 3.88). Mastery experiences ($M = 3.29$ – 3.49) and verbal persuasion ($M = 3.09$ – 3.23) were moderate, while internalized identity was the weakest dimension ($M = 2.98$ – 3.41). A Mann-Whitney U test showed a significant gender difference, with male students scoring higher than female students ($p = .008$, $r \approx .20$). These findings suggest that students generally perceive chemistry as valuable, but internalizing a “chemistry person” identity remains less developed and requires more structured mastery experiences, credible recognition, and supportive learning environments for development.

Keywords: Chemistry identity; Chemistry learning; Cohort; Cross-sectional survey; Prospective chemistry teachers

Introduction

Teacher education programs play a strategic role not only in equipping prospective teachers with subject-matter knowledge and pedagogical skills, but also in shaping how they make sense of themselves as educators and as members of a scholarly community. In science education, identity is widely recognized as an important factor associated with learning engagement, persistence, and the ways individuals position themselves within scientific communities (Carlone & Johnson, 2007; Hazari et al., 2013). Identity continues to develop through ongoing learning experiences and sustained social interactions (Avraamidou, 2018). Studies on science teacher identity further show that program context, practicum experiences, interactions

with peers and lecturers, and self-reflection are important sources that shape professional identity during teacher preparation (Zhai et al., 2024). Therefore, understanding how identity is formed during teacher education is important for strengthening the quality of science education.

Science identity is commonly conceptualized as a multidimensional construct shaped by experiences of competence, performance, and social recognition. Carlone & Johnson (2007), formulated science identity through three interrelated dimensions, namely competence, performance, and recognition, which have since been widely adopted and further developed in subsequent studies. In addition, discipline specific identity models, such as those in physics, include interest as an important component alongside

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competence and performance as well as recognition, and show that students' learning experiences are closely linked to how they come to see themselves as a "science person" and to their career choices in science (Hazari et al., 2010). Empirically, science identity is also associated with affective factors relevant to learning success, such as self-efficacy and a sense of belonging, suggesting that a focus limited to conceptual achievement is often insufficient to explain why some students persist while others disengage from science (Trujillo & Tanner, 2014).

The chemistry context presents distinctive challenges that make identity discussions increasingly relevant for preservice chemistry teachers. Chemistry learning requires learners to connect macroscopic, submicroscopic, and symbolic representations, while many concepts are abstract and may impose a high cognitive load (Gilbert & Treagust, 2009; Johnstone, 1991). Because chemistry learning experiences have disciplined specific characteristics, identity measures that are too general may fail to capture the experiences that matter most in chemistry learning. Therefore, a discipline-specific measurement approach is important so that identity dynamics in the chemistry context can be mapped more accurately (Hosbein & Barbera, 2020b).

Chemistry identity is a discipline-specific construct derived from the broader science identity framework. It refers to how individuals perceive themselves as "chemistry persons" within chemistry learning contexts. To measure chemistry identity in a more targeted way, Hosbein & Barbera (2020a) developed the Measure of Chemistry Identity (MoChI) instrument. In MoChI, chemistry identity is linked to relevant sources of experience, namely mastery experiences, verbal persuasion, and interest, which is differentiated into feeling-related and value-related dimensions. These four subconstructs are complemented by an identity indicator reflecting the internalization of self-perception as a chemistry person (Hosbein & Barbera, 2020a). Because this instrument was developed and evaluated in the context of university-level chemistry courses, it is relevant for profiling chemistry identity among prospective chemistry teachers in a more discipline-specific way.

Chemistry identity is important because it is associated with persistence, engagement, and academic or career direction in science-related fields. Prior studies have shown that science identity contributes to persistence and aspirations in science-related fields (Aschbacher et al., 2010; Chemers et al., 2011), engagement in learning (Trujillo & Tanner, 2014), and students' propensity to participate in additional science activities both inside and outside the classroom (Vincent-Ruz & Schunn, 2018, 2021). In addition, gender-related challenges in STEM remain an important concern. According to UNESCO (2020), women and girls

pursuing STEM careers often face discrimination, harmful gender stereotypes, and limited support and representation. Such conditions may discourage women from sustained participation in STEM and may also shape students' opportunities to experience recognition, belonging, and meaningful participation in chemistry learning. Accordingly, students with a stronger chemistry identity are more likely to position themselves as part of the scientific community and to sustain more stable motivation to engage in chemistry learning practices over time.

Although various efforts have been made to strengthen students' identity and persistence in STEM, such as mentoring, utility-value interventions, and belonging-focused support (Harackiewicz et al., 2023; LaCosse et al., 2020; Shortlidge et al., 2024), fewer studies have specifically profiled chemistry identity among prospective chemistry teachers using a discipline-specific framework, particularly in the Indonesian context. Prior studies in the local chemistry education context suggest that students' responses to chemistry learning are shaped by the experience and intensity of learning (Huda et al., 2023), the meaningfulness of practical work (Lestari et al., 2025), and the conditions under which learning is implemented, including practicum settings (Sari et al., 2022), learning environments (Dewi et al., 2023), and digitally designed teaching materials and worksheets (Nasution et al., 2023). This suggests that students from different entry cohorts may not experience chemistry learning in the same way, making cohort-based profiling relevant for identifying which dimensions are already strong and which still require support within teacher education.

The novelty of this study lies in profiling the chemistry identity of prospective chemistry teachers across multiple entry cohorts using the MoChI framework in an Indonesian teacher education context, while also examining whether these patterns differ by gender. Based on this rationale, this study aims to map the chemistry identity profiles of prospective chemistry teachers across entry cohorts. Specifically, this study: describes overall chemistry identity, the four MoChI subconstructs (mastery experiences, verbal persuasion, feeling-related interest, and value-related interest), and the identity indicator reflecting self-recognition as a chemistry person across cohorts; examines whether chemistry identity profiles differ across cohort groups; and examines whether chemistry identity differs by gender. This profiling is expected to provide practical implications for chemistry teacher education in designing more balanced learning experiences that intentionally support the development of professional chemistry teacher identity.

Method

This study used a quantitative cross-sectional survey design to map the chemistry identity profiles of students in the Chemistry Education program at

Universitas Tanjungpura. This design was selected because it allows efficient measurement of affective constructs in a relatively large group of respondents within a single data collection period. The overall research procedure is presented in Figure 1.

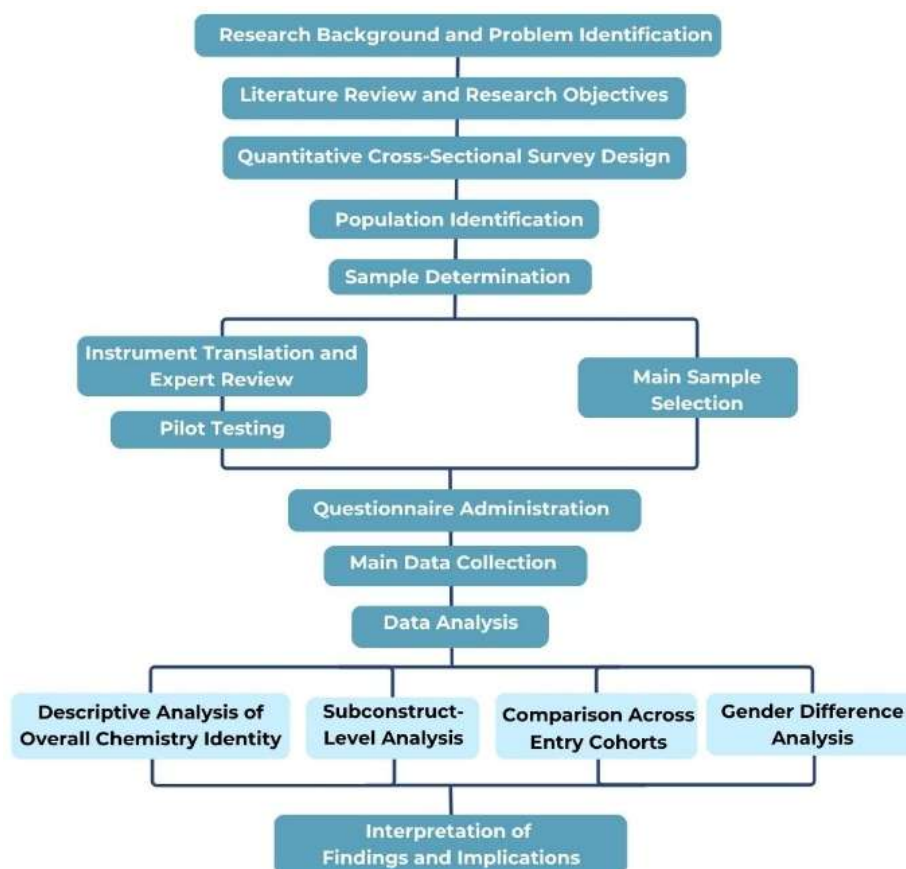


Figure 1. Research flowchart

Participants

The study was conducted in the Chemistry Education Study Program at Universitas Tanjungpura, West Kalimantan, Indonesia, at the end of the first semester of the 2025/2026 academic year. The population comprised all active students enrolled from four entry cohorts, namely those admitted in 2022, 2023, 2024, and 2025. At the time of data collection, these cohorts were in semesters 7, 5, 3, and 1, respectively. The sample was selected using convenience sampling, with efforts made to include participants from each cohort. Eligible participants were students who were actively enrolled in the program, belonged to one of the four specified entry cohorts, and completed the questionnaire in full. A total of 176 students participated in the study (N = 176). The distribution of participants by cohort is presented in Table 1, and the gender composition is shown in Figure 2.

Table 1. Student demographic information

Entry Level (Cohort)	Frequency	Percentage (%)
2025 (first year)	45	25.57
2024 (second year)	43	24.43
2023 (third year)	44	25
2022 (fourth year)	44	25
Total Participants	176	100

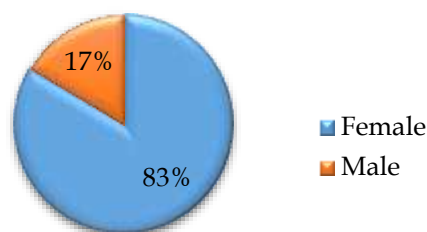


Figure 2. Gender distribution of participants (N = 176)

Instruments

Chemistry identity was measured using the Measure of Chemistry Identity (MoChI) developed by Hosbein & Barbera (2020b). The instrument consists of 20 items covering mastery experiences (6 items), verbal persuasion (6 items), feeling-related interest (4 items), value-related interest (3 items), and one identity indicator reflecting self-recognition as a chemistry person. All items were rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The MoChI instrument was translated into Indonesian by a certified translator. To ensure conceptual clarity and contextual appropriateness, the translated version was subsequently reviewed by experts in chemistry education.

The questionnaire was administered online via a Google Forms link to students from four cohorts. During the one-month data collection period, some students completed the questionnaire during scheduled class meetings, while others completed it online outside class. Regardless of the setting, all participants completed the same questionnaire using the same online form within the same data collection period.

A pilot test was conducted with 36 respondents. Item performance was evaluated using item-total correlations, with coefficients ranging from 0.37 to 0.79, all of which exceeded the critical *r* value of 0.33. Internal consistency reliability was assessed using Cronbach’s alpha. The alpha coefficients for mastery experiences, verbal persuasion, feeling-related interest, and value-related interest were 0.79, 0.88, 0.82, and 0.72, respectively. The Cronbach’s alpha coefficient for the total MoChI scale was .91, indicating that the instrument demonstrated high reliability. According to George and Mallery (2003), a Cronbach’s alpha is considered acceptable when $0.70 \leq \alpha < 0.80$ and good when $0.80 \leq \alpha < 0.90$. Because the identity indicator consisted of a single item, a separate Cronbach’s alpha coefficient was not calculated for this component.

Data Analysis

Data were processed in Microsoft Excel and analyzed using SPSS. Mean scores were calculated to describe students’ chemistry identity levels according to the classification criteria shown in Table 2.

Table 2. Analysis of Likert scale

Mean Score	The level of agreement
0.00 - 1.50	Very low
1.51 - 2.50	Low
2.51 - 3.50	Moderate
3.51 - 4.50	High
4.51 - 5.00	Very High

(Sanpanich, 2021)

Inferential analyses were then conducted to examine differences in chemistry identity across cohorts. MoChI scores were analyzed both overall and by component and compared across the four entry cohorts. When parametric assumptions were satisfied, differences in mean scores were tested using one-way ANOVA; otherwise, the Kruskal–Wallis test was employed. To examine whether chemistry identity differed by gender, the Mann–Whitney U test was used because gender was treated as a categorical variable with two independent groups and the chemistry identity scores were not normally distributed.

Result and Discussion

Chemistry Identity by Cohort (Year of Entry)

This section presents the chemistry identity profiles of students across four entry cohorts (2022–2025) using the Measure of Chemistry Identity (MoChI). Chemistry identity was analyzed based on the mean scores of the MoChI subconstruct, namely mastery experiences, verbal persuasion, feeling-related interest, value-related interest, and the identity indicator reflecting self-perception as a chemistry person. Overall, the mean chemistry identity scores showed a slight upward trend across cohorts. A comparison of the mean scores across cohorts is presented in Figure 3.

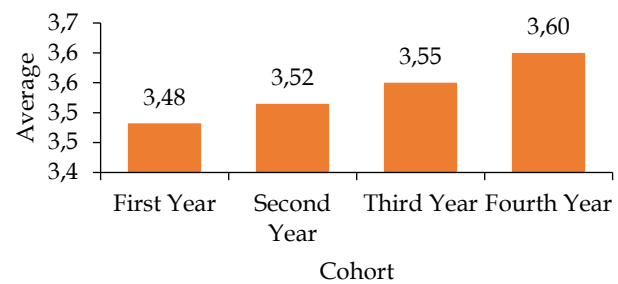


Figure 3. Mean chemistry identity scores by year level (Corresponding to the 2022–2025 entry Cohorts) based on the total MoChI score (N = 176)

Based on Figure 3, the overall mean chemistry identity score was slightly higher among students in the fourth year (2022 entry cohort; M = 3.60), followed by the third year (2023 entry cohort; M = 3.55), second year (2024 entry cohort; M = 3.52), and first year (2025 entry cohort; M = 3.48). Although the scores showed a small descriptive increase across cohorts, the differences were minimal. The Kruskal–Wallis test indicated that the distribution of chemistry identity scores did not differ significantly across cohorts, $H(3) = 1.191$, $p = .755$, with a negligible effect size ($\epsilon^2 \approx .00$). These findings suggest that, at a single point of measurement, entry cohort was not meaningfully associated with variation in chemistry

identity scores. Therefore, the pattern shown in Figure 3 should be interpreted as descriptive variation across cohorts rather than as evidence of developmental or longitudinal change.

Although chemistry identity did not differ across cohorts in this study, science identity remains important because it is related to career choices in science (Stets et al., 2017) and to how individuals draw on science in everyday life (Williams & George-Jackson, 2014). Prior studies have suggested that identity may strengthen as students accumulate learning experiences, conceptual understanding, and social recognition within academic settings (Carlone & Johnson, 2007), and some longitudinal research has reported identity growth among certain students during university chemistry learning (Robinson et al., 2019). Nevertheless, because the present study employed a cross-sectional design, the small between-cohort differences may also reflect cohort composition (e.g., selection/retention effects whereby students who feel a better fit remain into later years). Therefore, a more informative interpretation requires examining the profiles of the sub-constructs that shape chemistry identity. The following subsections discuss mastery experiences (ME), verbal persuasion (VP), situational interest (feeling-related interest/FRI and value-related interest/VRI), and the identity indicator (ID).

Gender Differences in Chemistry Identity

In addition to the cohort-based comparisons, this study also examined whether chemistry identity differed by students' demographic characteristics, particularly gender. The comparison of mean chemistry identity scores by gender is presented in Figure 4.

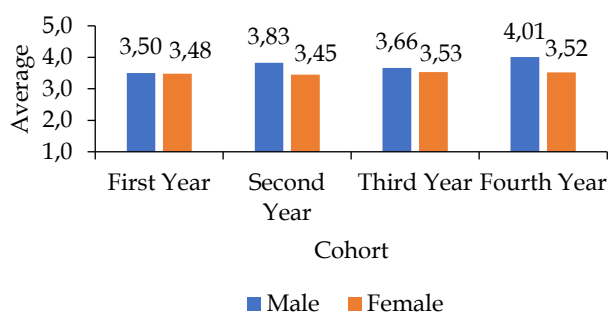


Figure 4. Mean chemistry identity scores by gender across year levels (N = 176)

Overall, male students showed a higher mean chemistry identity score than female students (M = 3.73 vs. 3.50), placing male students in the high category and female students at the upper limit of the moderate category. Across year levels, male students consistently obtained higher mean scores than female students. In the

first year, both male (M = 3.50) and female students (M = 3.48) were in the moderate category. In the second year, male students were in the high category (M = 3.83), whereas female students remained in the moderate category (M = 3.45). In the third and fourth years, both groups were in the high category, although male students continued to report higher mean scores than female students (third year: M = 3.66 vs. 3.53; fourth year: M = 4.01 vs. 3.52). The largest gap was observed in the fourth year ($\Delta M = 0.49$), whereas the smallest gap occurred in the first year ($\Delta M = 0.02$).

To determine whether these differences were statistically significant, a Mann-Whitney U test was conducted. The results showed a significant difference in chemistry identity scores between male and female students, with male students having higher rank scores than female students (mean rank = 111.48 vs. 83.97), $U = 1465.00$, $Z = -2.660$, $p = .008$, with a small effect size ($r \approx .20$). These findings indicate that chemistry identity differed significantly by gender, although the magnitude of the difference was relatively small. Descriptively, male students also showed higher mean chemistry identity scores than female students across cohorts.

This finding is consistent with studies from some contexts reporting that male students may show stronger science identity or higher self-assessments of ability than female students (Alhadabi, 2023; Hidayat, 2022; Taufiq et al., 2020). However, such differences should not be interpreted as universal or inherent, as identity development is shaped by a combination of personal, academic, and sociocultural experiences (Gallagher et al., 2017). The wider gap observed in the senior cohort, where female students showed lower chemistry identity scores than male students, may be better understood from a sociocultural perspective than as a direct effect of gender alone. Research in general chemistry has shown that women often report lower sense of belonging and higher belonging uncertainty than men, and that these experiences are linked to persistence and performance in chemistry courses (Fink et al., 2020). Chemistry education studies have also emphasized that recognition plays a central role in shaping whether students feel seen, affirmed, and valued as "chemistry persons" (Jones et al., 2025). More broadly, women in science may also confront negative stereotypes about their abilities and limited social support (Barmby et al., 2008). Accordingly, the lower chemistry identity scores among female students, particularly in the senior cohort, may reflect differences in social-academic experiences, such as unequal access to affirmation, limited female role models in advanced chemistry settings, or variation in recognition and support within learning environments. Because this study employed a cross-sectional design, these findings

should be interpreted as descriptive group differences at a single point in time rather than as evidence of developmental change.

Profile of the Chemistry Identity Sub-Constructs (MoChI) Mastery Experiences (ME)

Mastery experiences refer to experiences of success and failure that shape individuals' perceptions of their capability. In self-efficacy theory, mastery experience is considered the most influential source in developing the belief that "I can do it," which is associated with greater effort and persistence when individuals face challenging tasks (Bandura, 1977). For the mastery experiences subconstruct, the mean scores across cohorts ranged from 3.29 to 3.49, which were all classified in the moderate category based on the criteria in Table 2. A comparison of mastery experiences across cohorts is presented in Figure 5.

Descriptively, cohorts with longer time in the program showed slightly higher mastery experiences than cohorts with shorter time in the program. The mean scores increased gradually from the first year ($M = 3.29$) to the second year ($M = 3.31$), third year ($M = 3.38$), and fourth year ($M = 3.49$). However, a one-way ANOVA indicated that the differences across cohorts were not statistically significant, $F(3, 172) = 1.561$, $p = .201$, $\eta^2 = .027$, indicating a small effect size. These results suggest that, in this sample, mastery experiences did not differ meaningfully across cohorts, although a slight upward trend was descriptively observed. The tendency for somewhat higher mastery experiences among students in later years may be related to accumulated academic experiences and longer exposure to coursework and laboratory activities, which can enrich students' perceptions of success in learning chemistry.

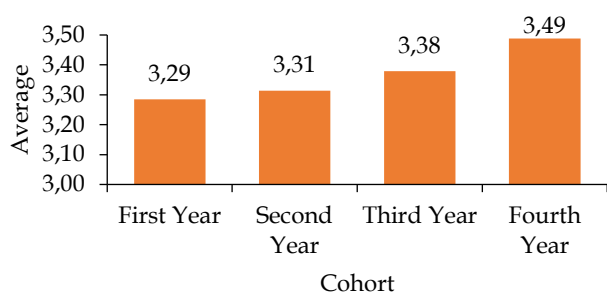


Figure 5. Mean scores of students' Mastery Experiences (ME) by Cohort ($N = 176$)

This interpretation is consistent with evidence from teacher education contexts showing that mastery experiences in authentic practice, together with constructive support and feedback (i.e., social/verbal persuasion), are associated with changes in self-efficacy particularly when learning is supported by effective

mentoring (Yerdelen et al., 2024). This is relevant to chemistry identity because meaningful success experiences can strengthen competence perceptions that support identity development. In the science identity framework, competence and performance are key dimensions of identity; mastery experiences provide a basis for developing such competence perceptions (Carlone & Johnson, 2007). Evidence from other domains also highlights mastery experiences as a particularly strong source of self-efficacy relative to other sources (Egele et al., 2025).

Verbal Persuasion (VP)

Verbal persuasion (VP) reflects support, reinforcement, and feedback from lecturers and peers that can influence students' beliefs about their capability, particularly when such feedback is specific and (Usher & Pajares, 2009). For the verbal persuasion component, the mean scores across cohorts ranged from 3.09 to 3.23, which were all classified in the moderate category based on the criteria in Table 2. The highest mean score was observed in the fourth year ($M = 3.23$), whereas the lowest was found in the second year ($M = 3.09$) (Figure 6). A comparison of verbal persuasion across cohorts is presented in Figure 6.

Descriptively, the pattern of verbal persuasion scores did not show a consistent increase across cohorts. The mean score was 3.19 in the first year, decreased slightly to 3.09 in the second year, rose to 3.16 in the third year, and reached 3.23 in the fourth year. However, the Kruskal-Wallis test indicated that the differences across cohorts were not statistically significant, $H(3) = 1.048$, $p = .790$. These findings suggest that verbal persuasion did not differ meaningfully across cohorts in this sample, and that the small variations observed were descriptive rather than indicative of systematic cohort differences.

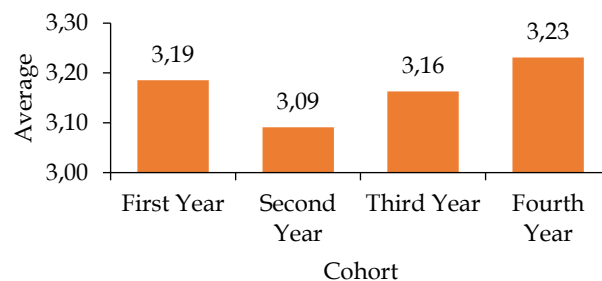


Figure 6. Mean scores of students' Verbal Persuasion (VP) by Cohort ($N = 176$)

The modest variation across cohorts may reflect differences in learning experiences and classroom dynamics, such as the intensity and specificity of feedback, patterns of instructional interaction, and opportunities for competence recognition during class

activities. Consistent with this interpretation, Guo et al. (2022) showed that verbal recognition tends to have a stronger impact when learners already possess an initial foundation of confidence in their competence. Although VP did not differ across cohorts, it warrants attention because it aligns conceptually with the recognition dimension in science identity formation (Carlone & Johnson, 2007). Bandura (1997) emphasized that social persuasion is most effective when it is realistic and consistent with performance experiences. When recognition and support are not perceived as credible, students may find it more difficult to internalize the identity of a “chemistry person.” Prior studies also suggest that recognition from important others and support from individuals perceived as experts can strengthen engagement and science identity (Baker et al., 2024; Lucas & Vandergon, 2024).

These findings imply that learning environments should be designed to increase opportunities for students to receive authentic reinforcement and recognition. Self-recognition and recognition from others can be fostered through collaborative activities with peers that reflect real-world practices in science careers (Rodriguez et al., 2019). This is supported by evidence from the same institutional context, showing that Chemistry Education students at FKIP UNTAN demonstrated generally high collaboration skills in basic chemistry practicum, particularly in discussion, teamwork, communication, and responsibility (Hadiwangsa et al., 2024). Such collaborative laboratory experiences may therefore provide meaningful opportunities for participation, peer recognition, and a stronger sense of belonging in chemistry. Likewise, the authentic use of scientific tools and laboratory activities can strengthen students’ sense of “being a scientist,” thereby supporting the internalization of chemistry identity (Cairns et al., 2021). Learning environments aligned with scientific practice may also increase students’ sense of fit and connection, making self-recognition as part of the chemistry community more likely (Perin et al., 2020). In addition, recognition from individuals viewed as experts such as validating well-executed experimental skills can further strengthen students’ confidence (Chapman & Feldman, 2017). In chemistry courses, these strategies can be supported through clear laboratory rubrics, specific and realistic formative feedback, and structured discussion or peer-review processes that allow competence recognition to occur consistently across cohorts.

Feeling-Related Interest (FRI)

Feeling-related interest (FRI) reflects interest rooted in affective experiences, such as enjoyment of learning (Schiefele, 1991). In the feeling-related interest (FRI) component, the mean scores ranged from 3.72 to 3.88,

and all cohort means fell into the high category. The highest mean score was observed in the 2024 entry cohort ($M = 3.88$), whereas the lowest was found in the 2022 entry cohort ($M = 3.72$). A comparison of FRI across cohorts is presented in Figure 7. Descriptively, FRI showed only slight variation across cohorts. The mean scores were 3.80 for the 2025 entry cohort, 3.88 for the 2024 cohort, 3.75 for the 2023 cohort, and 3.72 for the 2022 cohort. However, the differences across cohorts were not statistically significant, $H(3) = 1.423$, $p = .700$, with a negligible effect size ($\epsilon^2 \approx 0.00$). These findings indicate that students’ affective interest in chemistry was relatively similar across cohorts, despite minor descriptive fluctuations.

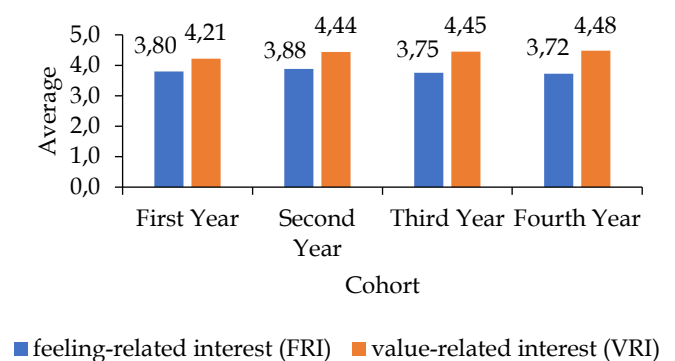


Figure 7. Percentage of students’ situational interest by Cohort (N = 176)

These descriptive differences suggest that affective interest may be influenced by situational triggers, such as task characteristics, variety of activities, classroom social interactions, and a sense of novelty. Rotgans & Schmidt (2011) emphasized the role of active classroom environments and instructional characteristics in facilitating situational interest. Similarly, situational interest can be triggered by novelty and variety, cognitive activation, hands-on activities, social interaction, and opportunities for choice (Guo & Fryer, 2025). This interpretation is also consistent with findings indicating that students’ interest in learning chemistry can be strengthened through contextual approaches in chemistry learning (Sari et al., 2023) and using innovative learning resources, such as pocket books (Handayani et al., 2021), augmented reality-supported modules (Whatoni & Sutrisno, 2022), and augmented reality-based flashcards (Rahmawati & Kamaludin, 2024). In addition, Permatasari et al. (2024) showed that the implementation of STEM-based learning strategies, models, and media can improve students’ understanding and make learning more effective in achieving instructional objectives. This finding reinforces the view that varied, contextual, and

innovative media-supported learning designs may not only foster students' learning interest but also support the development of scientific literacy and learning outcomes.

Value-Related Interest (VRI)

Value-Related Interest (VRI) reflects interest that emerges when students perceive chemistry as valuable and useful in terms of utility and academic or career relevance (Schiefele, 1991). The mean scores ranged from 4.21 to 4.48, and all cohort means fell into the high category. This component also had the highest scores among all subconstructs in the present study (2025 = 4.21; 2024 = 4.44; 2023 = 4.45; 2022 = 4.48). The highest mean score was observed in the 2022 entry cohort ($M = 4.48$), whereas the lowest was found in the 2025 entry cohort ($M = 4.21$). As shown in Figure 7, VRI remained consistently high across all cohorts. Descriptively, VRI also showed only slight variation across cohorts. The mean scores were 4.21 for the 2025 entry cohort, 4.44 for the 2024 cohort, 4.45 for the 2023 cohort, and 4.48 for the 2022 cohort. However, the differences across cohorts were not statistically significant, $H(3) = 3.538$, $p = .316$, with a negligible effect size ($\epsilon^2 \approx .003$). These findings indicate that students across cohorts consistently perceived chemistry as valuable and relevant, with only minor descriptive variation. Importantly, VRI consistently showed the highest mean scores among all subconstructs across cohorts, confirming that value-related interest was the strongest component in this study. This component is important to maintain through meaningful application contexts, while strengthening other dimensions that are relatively lower, such as social and academic recognition and reinforcement.

Descriptively, the higher VRI in cohorts with longer time in the program may reflect increasing perceptions of utility and meaningfulness as academic experience accumulates (Hunsu et al., 2017), greater exposure to contextualized learning activities that can trigger situational interest (Rotgans & Schmidt, 2011), and more favorable control and competence appraisals that support engagement and positive emotions in learning (Pekrun et al., 2007). In chemistry learning contexts, experiences that connect chemical concepts with socio-scientific issues, particularly environmental issues, may also strengthen students' perceptions that chemistry is valuable and relevant for understanding and responding to real-world problems. This is consistent with findings showing that guided inquiry learning using environment-related socio-scientific issues can improve pre-service chemistry teachers' environmental awareness, particularly in terms of their perception of environmental issues and environmental optimism (Sulistina et al., 2021). Overall, the findings suggest strong "value capital" across cohorts. Accordingly,

instructional efforts may prioritize strengthening relatively lower dimensions, such as recognition and support, while maintaining students' value perceptions of chemistry through meaningful, contextualized, and applied learning experiences.

Internalized Identity/Identity Indicator (ID)

The identity indicator in the MoChI framework reflects the extent to which students internalize self-recognition as a "chemistry person." In this sense, the indicator captures not merely a technical measurement label, but a psychologically meaningful expression of internalized chemistry identity. Conceptually, this dimension may also be interpreted alongside mindset, particularly whether being a "chemistry person" is viewed as a fixed personal trait or as something that can be strengthened through persistence and effective learning strategies (Dweck, 2013). A comparison of the mean scores for this dimension across cohorts is presented in Figure 8.

Descriptively, the mean scores for this dimension ranged from 2.98 to 3.41, and all cohort means fell into the moderate category based on the criteria in Table 2. The lowest mean score was observed in the 2025 entry cohort ($M = 2.98$), whereas the highest was found in the 2023 entry cohort ($M = 3.41$). The 2022 entry cohort also showed a relatively similar mean ($M = 3.34$), indicating some descriptive variation across cohorts. However, the Kruskal-Wallis test indicated that the differences across cohorts were not statistically significant, $H(3) = 5.687$, $p = .128$, with a small effect size ($\epsilon^2 \approx .016$). These findings suggest that students' internalized identity as a chemistry person did not differ meaningfully across cohorts at the time of measurement.

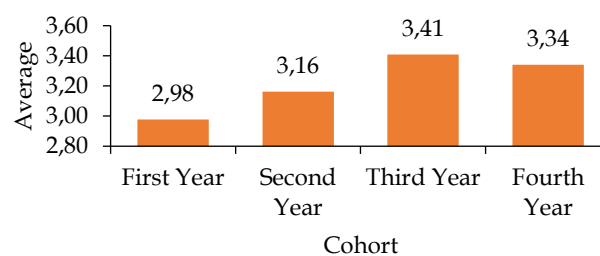


Figure 8. Mean scores of students' Internalized Identity (ID) by Cohort ($N = 176$)

Compared with the other subconstructs, this dimension showed the lowest mean scores, indicating that some students may not yet fully internalize the view of themselves as "chemistry persons," even when they report relatively high value-related interest in chemistry. Within the MoChI framework, stronger internalized identity is expected when students experience meaningful mastery experiences, receive credible social affirmation and recognition, and maintain sustained

interest in chemistry (Hosbein & Barbera, 2020b). In this study, the comparatively lower scores on this dimension suggest that perceiving chemistry as valuable does not automatically translate into a firmly internalized chemistry identity.

These findings point to the need for learning interventions that support students' confidence and persistence. Interventions emphasizing growth mindset and adaptive learning strategies may enhance persistence and academic performance, particularly among students with low confidence (Claro et al., 2016; Dweck, 2009; Paunesku et al., 2015). However, because this study used a cross-sectional design, the observed differences should be interpreted as descriptive variation across cohorts rather than as evidence of identity development over time.

Taken together, these subconstruct-level findings indicate that students across cohorts generally reported strong value-based engagement and positive affective interest in chemistry, although the internalization of chemistry identity itself appeared relatively more limited. Across cohorts, the descriptive pattern was broadly similar: value-related interest was consistently the strongest component, followed by feeling-related interest, whereas mastery experiences and verbal persuasion remained moderate, and internalized identity was the weakest dimension. This suggests that, although students may already perceive chemistry as valuable and relevant, such perceptions do not automatically translate into a firmly internalized sense of self as a "chemistry person." In this regard, learning environments may need to provide more consistent and credible affirmation, formative feedback, and opportunities for competence recognition. Instructional designs that intentionally support these experiences in both classroom and laboratory contexts may help strengthen students' chemistry identity more meaningfully.

Conclusion

Chemistry identity among prospective chemistry teachers did not differ significantly across the first-through fourth-year cohorts, either in the overall score or in any MoChI subconstruct. Descriptively, value-related interest was the strongest component, followed by feeling-related interest, whereas mastery experiences and verbal persuasion were moderate, and internalized identity was the weakest dimension. In addition, chemistry identity differed significantly by gender, with male students scoring higher than female students, although the effect size was small. These findings suggest that students generally perceive chemistry as valuable, yet their internalization of a "chemistry person" identity is not as strong as their value

perceptions and affective engagement. This indicates that identity development should not stop at "chemistry is important," but should move toward "I am capable and I am recognized in chemistry." Accordingly, chemistry teacher education programs need to provide structured and meaningful mastery experiences, together with specific, credible feedback and recognition, to strengthen students' chemistry identity. Future research is recommended to employ longitudinal designs to capture the development of chemistry identity over time. Studies involving more diverse institutions and regions are also needed to improve contextual generalizability. In addition, qualitative approaches may help explain how recognition, belonging, and social-academic support shape chemistry identity, particularly across cohorts and gender groups.

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Author Contributions

Conceptualization, methodology, software, formal analysis, investigation, resources, data curation, writing - original draft, A.F.W.; writing - review & editing, visualization, validation, supervision, Project administration, O.S. and A.R.W. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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