# Mathematics and Science Teaching Anxiety Toward Pre-service Mathematics and Science Teachers

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## Abstract

Japanese high schools started teaching the subject "Inquiry-Based Study" this year. However, future mathematics teachers have difficulties teaching science content and vice versa. The current study revealed mathematics and science teaching anxieties (MSTAs) in pre-service mathematics and science teachers. A total of 82 pre-service mathematics and science teachers taking the Instructional Design and Technology Course at the Faculty of Science, Japanese private University A, participated in this research. The questionnaires comprised three items: (1) technological pedagogical content knowledge (TPACK), (2) MTA, and (3) STA. As a result of EFA on pre-service mathematics and science teachers' MSTA questionnaire scores, MSTA was found to be comprised of two factors: (1) anxiety related to teaching processes and (2) anxiety related to teaching content. The result of ANOVA on the MSTA factors revealed that the MTA is significantly higher than STA. Moreover, the TA of the sub subject is significantly higher than that of the main subject.

*Keywords: Mathematics Teaching Anxiety, Inquiry-Based Study, Pre-Service Teacher Education, Science Teaching Anxiety*

## Research Background

Japanese high schools started teaching the subject "Inquiry-Based Study" this year. Primarily, the high school subject "Inquiry-Based Study of Science and Mathematics" aims to develop in students the ability and skills necessary to solve problems through the inquiry process, interaction with various events, and combining mathematical and scientific thinking and perspectives (MEXT, 2018). The goal is to foster problem-solving skills through understanding events and through hybrid and creative approaches, defining and inquiring about problems related to mathematics or science and enhancing creativity. High school teachers, therefore, need to understand mathematics and science, expecting cross-curriculum learning.

However, teachers experience teaching anxiety (TA) when teaching mathematics. Peker (2006) defines mathematics TA (MTA) as teachers' tension and anxiety while teaching mathematical concepts, theories, and formulas or during problem-solving. Patkin and Greenstein (2020) argue that the MTA of pre-service teachers is higher than that of in-service teachers. Moreover, Sari and Aksoy (2016) state that the higher teachers' MTA, the more they adopt teacher-centered instructions. In the paradigm of student-centered instruction, teacher-centered instruction has a problem in terms of evaluation.

These TAs can also be considered in science. Liu (2016) highlights that in-service primary teachers report more MTA and science teaching anxiety (STA) than "reading anxiety" and "social studies anxiety." This result indicates that teachers need to consider MTA and STA to teach all subjects at the same level. However, future mathematics teachers have difficulties teaching science content and vice versa. The current study revealed mathematics and science teaching anxieties (MSTAs) in pre-service mathematics and science teachers.

## Method

A total of 82 pre-service mathematics and science teachers taking the Instructional Design and Technology Course at the Faculty of Science, Japanese private University A, participated in this research. Held from April to June 2022, the aforementioned course was required for a junior on a pre-service teacher-training course at University A. The teachers filled out the pre- and post-questionnaires before and after the course, respectively.

The questionnaires comprised three items: (1) technological pedagogical content knowledge (TPACK), (2) MTA, and (3) STA. TPACK represents the interacted technological, pedagogical, and content knowledge required by teachers. We used the English TPACK scale "TPACK.xs" (Schmid et al., 2020) translated into Japanese by the authors. "TPACK.xs" comprised 28 items rated on a 5-point Likert scale. MTA and STA were examined using a 5-point Likert scale comprised of 19 items of each. The original MTA Scale (Hunt & Sari, 2019) was published in English, so the authors translated it into Japanese. For STA, the same question items as MTA were adopted, using "science" instead of "math" (e.g., question item, "I am afraid to go beyond the content of math/science textbooks.").

## Results

Data analysis was conducted on 41 pre-service mathematics teachers and ten science teachers who completed the pre- and post-questionnaires. To identify the factors of MSTA, exploratory factor analysis (EFA) was conducted on the post-TA score of the teachers' specific subject, using maximum likelihood extraction in combination with a Promax rotation. Factor number was defined based on the eigenvalues > 1. The first EFA results revealed four-factor loadings of less than .35 (items 2, 8, 9, and 16). We then conducted EFA again, eliminating the four aforementioned TA items. This second result used as the EFA result indicated that all factor loadings were greater than .35. Assumption check using Bartlett's test of sphericity showed significant value, $\chi^2$ (105) = 381.33, $p < .001$, and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of all items was >.60 ($KMO_{max}$ = .89, $KMO_{min}$ = .61). Therefore, these data were available for EFA.

### Exploratory Factor Analysis of Mathematics Science Teaching Anxieties

The results of the final EFA are reported in **Table 1**. Model fit measures are good as root mean square error of approximation (RMSEA) < .05, Tucker-Lewis Index (TLI) > .95, and $\chi^2$ is not significant. The result indicates that the MSTA comprises two factors. The first MSTA factor was named "anxiety related to teaching processes" and the second, "anxiety related to teaching content."

We confirmed the above factor naming via correlation analysis of Kendall's coefficient $\tau$ to seven TPACK components (i.e., PK, CK, TK, PCK, TPK, TCK, TPCK) and two MSTA factors. The results demonstrate that the second MSTA factor, "anxiety related to teaching content," has a significant positive correlation to CK, $\tau$ = .48, $p < .001$, whereas the other TPACK components have no significant or good extended correlation ($\tau < .40$). This result indicates that the second MSTA factor is somewhat related to CK.

**Table 1.**
*EFA of pre-service mathematics and science teachers' teaching anxiety*

| Factor loadings | $F_1$ | $F_2$ | C |
|---|---|---|---|
| 14. I feel nervous when a pre-service/trainee teacher observes my specific subject teaching. | **.94** | -.07 | .81 |
| 3. The thought that students will not meet curriculum/school targets in my specific subject worries me. | **.81** | -.01 | .65 |
| 17. Thinking about how to use tools/materials that I don't know how to use in my specific subject classroom makes me feel anxious. | **.79** | .04 | .66 |
| 1. The thought of not being able to motivate students to learn my specific subject bothers me. | **.71** | -.07 | .45 |
| 6. Differences in students' prior knowledge worry me when preparing for my specific subject lessons. | **.55** | -.22 | .21 |
| 19. I feel uneasy when students don't understand concepts of my specific subject, and I have to find/think about alternative methods or strategies to teach them. | **.53** | .25 | .49 |
| 5. I worry that students in my specific subject class will fail their assessments. | **.50** | .13 | .34 |
| 4. The thought that students will not pay attention to what I am teaching in my specific subject class worries me. | **.45** | .16 | .31 |
| 7. I worry that students will answer questions about my specific subject incorrectly. | **.42** | .22 | .33 |
| 11. I avoid talking about my specific subject teaching with other teachers outside the classroom. | -.39 | **1.00** | .70 |
| 12. I avoid classroom discussion if students pose challenging questions about my specific subject. | -.11 | **.89** | .69 |
| 15. I feel uncomfortable when one of my colleagues comes to my classroom during my specific subject lesson. | .03 | **.66** | .46 |
| 18. The thought of using concrete tools in my specific subject classes worries me. | .17 | **.61** | .53 |
| 10. I am afraid to go beyond the content of my specific subject textbooks. | .25 | **.50** | .46 |
| 13. I get uneasy knowing that the next lesson is my specific subject. | .20 | **.45** | .35 |
| α coefficient | .87 | .85 | |
| Sum of square loading | 4.17 | 3.28 | |
| Percentage total variance | .28 | .22 | |

*Note.* $n = 51$, $F_1$ = first factor, $F_2$ = second factor, C = community. Factor loadings > .40 are in boldface. RMSEA = .02 (90% CI[.00, .09]), TLI = .99, BIC = -220.00, $\chi^2$ (76) = 78.60, *n.s.* Kendall's correlation coefficient between $F_1$ and $F_2$ $\tau = .44$, $p < .001$.

## ANOVA of Mathematics Science Teaching Anxieties

The first and second MSTA factors were compared using a two-way analysis of variance (ANOVA). Factors were set as Subject (mathematics, science) and Specialty (main, sub). Assumption check tests for the first MSTA factor using Levene's homogeneity of variances test revealed no significant value, $F$ (3, 98) = 1.16, *n.s.*, and the Shapiro-Wilk normality test showed no significant value, $W = .99$, *n.s.*, which meant that the data were available for ANOVA. ANOVA of the first MSTA factor did not reveal significant interaction effects, $F$ (1, 98) = 0.00, *n.s.,* $\eta^2 = .00$. There was a significant difference in the Subject factor, $F$ (1, 98) = 8.72, $p < .01$, $\eta^2 = .08$, whereas there was no significant difference in the Specialty factor, $F$ (1, 98) = 1.32, *n.s.*, $\eta^2 = .01$. As the post hoc test of Subject factor indicates that MTA is significantly lower than STA, $M_{math} = 2.86$, $M_{science} = 3.51$, $t$ (98) = 2.95, $p < .01$, Cohen's $d = .74$, we note that the TA score is flipped so that low scores mean anxiety toward teaching.

The aforementioned assumption check tests for the second MSTA factor revealed no significant value, $F$ (3, 98) = 2.00, *n.s.*, and the Shapiro-Wilk normality test indicated significant value, $W = .97$, $p < .05$. Considering the robustness of ANOVA and the quantile-quantile plot, there were no special outliers; thus, we determined that the data were available for ANOVA. ANOVA of the second MSTA factor did not reveal significant interaction effects, $F$ (1, 98) = 0.40, *n.s.,* $\eta^2 = .00$. There was a significant difference in the Specialty factor, $F$ (1, 98) = 5.10, $p < .05$, $\eta^2 = .05$, whereas there was no significant difference in the Subject factor, $F$ (1, 98) = 3. 65, $p < .10$., $\eta^2 = .03$. As the post hoc test of Specialty factor indicates that TA of main subject is significantly lower than TA of sub subject, $M_{main} = 3.89$, $M_{sub} = 3.34$, $t\ (98) = 2.26$, $p < .05$, Cohen's $d = .56$, we note again that the TA score is flipped.

## Discussion

As a result of EFA on pre-service mathematics and science teachers' MSTA questionnaire scores, MSTA was found to be comprised of two factors: (1) anxiety related to teaching processes and (2) anxiety related to teaching content. This result is not the same as the factor structure of Hunt and Sari's (2019) English MTA Scale (teacher- or student-directed MTA). We consider that the difference has occurred due to the Japanese pre-service mathematics and science teacher context. As Hunt and Sari (2019) suggest, the MTA Scale two-factor structure does not apply directly to other countries.

The result of ANOVA on the first MSTA factor, anxiety related to teaching processes, revealed that the MTA is significantly higher than STA. Liu (2016) highlights that in-service teachers report more MTA than the other subject TA; Japanese pre-service teachers have high MTA, especially in teaching processes aspects. Moreover, the results of ANOVA on the second MSTA factor, anxiety related to teaching content, revealed that the TA of the sub subject is significantly higher than that of the main subject (i.e., pre-service mathematics teachers have high STA and vice versa). This result means that pre-service mathematics teachers have low confidence in science teaching contents and vice versa. Furthermore, pre-service teacher-training courses should consider both mathematics and science pre-service teachers learning mathematics and science content considering teaching cross-curriculum-based classes.

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