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Attitudes towards science in higher education: Validation of questionnaire among science teacher candidates and engineering students in Indonesia

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ABSTRACT

In higher education, academic success and failure can be affected by students' affective states, such as their attitudes towards courses and learning. Many studies highlight the role of attitudes in the educational process resulting in a high demand for attitude assessments to plan comprehensive instructional strategies. The present study assessed and compared attitudes towards science in higher education. A total of 296 Indonesian undergraduate students from science teacher training and engineering majors participated in this study by completing the online Attitudes Towards Science Questionnaire (ATSQ). The validation analysis with confirmatory factor analysis and the Rasch model was performed to measure the instrument's properties resulting in a good fit model for the questionnaire's theoretical construct with acceptable individual fit items. Comparing the attitudes of science teacher candidates and engineering students, no significant differences were found in attitude towards science. Both groups revealed moderate attitudes, with higher responses to the science value variable, followed by enjoyment and confidence, anxiety and difficulty, and participation in science learning and activities. However, there were differences in the pattern of correlations between the variables, especially for anxiety and difficulty. The ATSQ has good psychometric properties and therefore can be used in research to assess attitudes towards science. It can stimulate further research in different contexts to confirm empirical evidence and promote attitude development in higher education.

1. Introduction

The rapid growth in demand for pursuing higher education corresponds to the social dynamics, where many people are trying to achieve life goals, such as prospective jobs, social status, or even seeking self-improvement and knowledge [1]. Higher education provides a learning environment in specific fields such as natural sciences, social sciences, and engineering for people to lay the foundation for their future careers. Participation in higher education has been increasing recently, for example, in Indonesia between 2020 and 2021, university enrolment increased by 4.19% [2]. Although educational service provided by higher education institutions has improved, there are still disadvantages that had led to more students dropping out. In 2020, the dropout rate from the national universities and the international universities in Indonesia was 16.9% and 3.14% respectively, which many of them from engineering

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and education, especially science major [2]. The reasons identified for the high dropout rate in engineering and science education was mostly related to sub-optimal school environment, financial problems, health status, and low academic progress [3]. Personal status and inadequate educational support also play an important role in low academic progress, leading to a gradual decline in students' desire to participate in certain courses. In addition, the classroom atmosphere and attitude towards subjects is also connected to academic performance, which indirectly influence students' dropout rate [4]. Researcher also support the influence of attitude as one of psychological attributes that influence students' dropout [5]. Attitude mediates the engagement process during learning, which increases curiosity and extends new ways of learning, and reinforces the opportunity to gain new content and experience [6]. The decrease in attitude will potentially affect students' engagement in learning that cause low academic achievement and progress.

The importance of attitude towards learning in specific subject as an affective factor supporting academic success in education has been emphasized by several empirical studies [7,8]. Some studies have also found that positive attitude has a positive impact on students' academic performance at the undergraduate level [9]. Therefore, identifying students' attitudes plays an important role in maintaining students' learning performance in higher education. A profile of students' attitudes can provide useful information for teachers to improve their instructional strategies, which can lead to increased students' engagement and avoid dropouts. Thus, the assessment of attitude at the higher education level become substantial to planning further learning program and avoiding students' failure in maintaining their learning progression. The assessment of students' attitudes in higher education is complex process because it shows a high degree of variation and contextualization. University students enrolled in a particular degree according to their study program. The learning process were designed to match with their program and future profession, which is why attitude measurement needs to address this specific condition. For example, in science and engineering majors, the attitude measurement is likely related to science context.

In educational research, many attitude measurements exist, but a significant number of them often raise theoretical and methodological issues [10,11]. For most attitude measures, problems have been caused by a lack of clarity and definition, as well as by the fact that they have combined all attitude constructs into a single attribute and ignored the context [12]. Another criticism rose with the poor psychometric quality when some instruments failed to reach the current standards [13]. The validity of content is important to help determining whether the items are comprehensive and relevant enough to be put in the construct that the target participants do understand and can be interpret the items correctly. As many as attitude measures developed recently, the different result in validity was potentially found when the same attitude measurements were applied in different target groups meaning that the instruments will potentially behave differently among contexts. The recent study measured the validity properties of attitudes towards science in the Indonesian context and profiled students' attitude levels in higher education.

1.1. *Attitude towards science construct*

Attitudes have been described as spontaneous individual beliefs about attributes and objects [12]. They related to an individual's mental and emotional state, which influences the action towards subjects or objects [14]. In the context of science, attitudes can be explained as affective behaviours towards science scientists, science-related activities and careers, scientific inquiries, and enterprises. The change in the conceptualization of attitudes towards science happened in recent decades with the major transformation in attitudinal objects and their dimensions [15]. Attitude is known as a complex concept that can be explained by several frameworks. The most prominent and influential model of attitude construct probably is the dimension-based attitude which includes cognitive, affective, and behavioural dimensions [16,17]. A similar definition also highlights attitude as having three components: includes knowledge about the objects, principles, and ideas, feeling about the objects, and tendency towards actions [12,18]. These three dimensions are independent yet still closely related and form a solid framework of attitudes towards science (Fig. 1).

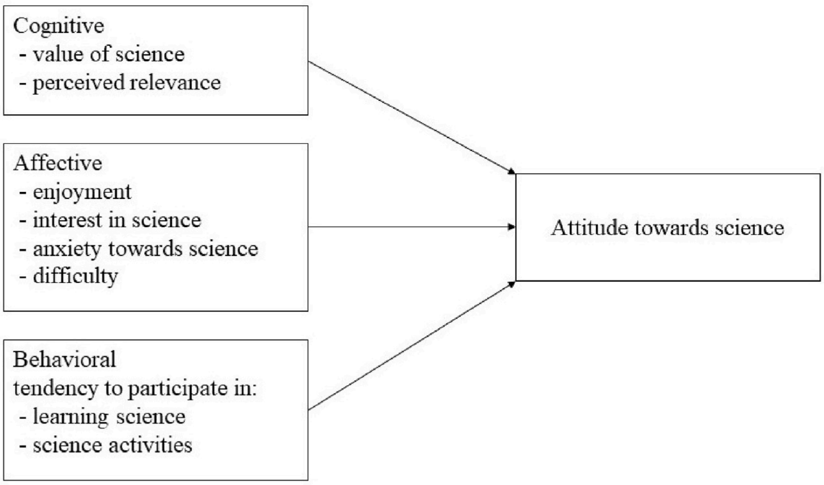

Fig. 1. The framework of three-dimensions of attitude towards science (based on personal attitude towards science [19]).

Cognition. This dimension refers to cognitive beliefs about science and its impact on human life and society. It is also defined as cognitive judgements that explain the decisions, conclusion, inferences, or understanding of scientific concepts and phenomena [20]. Cognitive judgements emerge from the process of giving value to the science objects. This concept is strongly related to personal knowledge and experience about science, indicating students' efforts in science studies [21]. In the cognitive dimensions, attitudes can be manifested in students' perceptions of the value and importance of science in everyday activities and social interactions. Students can identify whether science adds positive or negative value to their life and environment and whether the development and everyday application of science are relevant. A prominent variable in the explanation of the cognitive dimension of attitudes towards science is the value of science, which emphasizes the concept of science and its social implications [22]. The use of value of science in cognitive dimension has been shown to be applicable to the evaluation of attitude attitudes towards science [23,24].

Affect. The second dimension relates to positive and negative emotions about science. The positive emotions are manifested by the enjoyment of science and confidence in science, while negative emotions are represented by anxiety and difficulty with science. Both affective components are not opposite but rather display independent yet related sub-components. Some studies also reported that anxiety and enjoyment could be strong variable to be integrated into affective dimension of attitude towards science [22,25]. The concept of enjoyment is linked to subjective feelings about pleasure associated with phenomena, events, or a particular environment. It arises from the feeling of getting over controlled situations that provide interest and value [26]. Enjoyment is explained as a positive activated emotion based on focused activities which lead to the joy of experienced success or expected success [27]. In the context of enjoyment toward science, it is related to enthusiasm for science, an inner state of personal feeling about science when they feel good and experience happiness. There are several views about enjoyment being associated with accomplishment and confidence as a result of mastering skills, meeting challenges, or satisfaction with performances [16,28–30]. The term anxiety comes up with states of discomfort including fear, tension, worry, distress, frustration, and mental disorganisation [31]. In this context, anxiety is expressed in intellectual and personality areas. Intellectual factors of anxiety involve psychological arousal and negative cognition linked to poor performance, achievement, and potential of negative evaluation [32]. This type of anxiety is caused by difficulties in learning science and crosses into the personality domain, leading to negative feelings or aversion to science.

Behaviour. The behavioural tendency is a concept that can be used to indices attitude [33]. The behavioural tendency in attitude measurement points to openness in engaging with activities related to science [20]. This behaviour and activities are specifically intertwined with the learning process that addresses formal learning such as classroom learning and informal science learning through outdoor activities and hobbies.

The framework of the three-dimensions of attitude towards science instrument is focused on three main concepts: (1) whether students appreciate the importance of science in real life and society, (2) whether students are affectively connected to science, express their positive or negative emotions to science, and (3) whether students are involved and willing to participate in activities related to science or learning behaviour [20]. Likewise, it is expected that students who demonstrated good attitudes will present all attitudes in those three categories.

1.2. Research on attitude measurement

The effort to measure attitudes towards science has appeared in several contexts. From the perspective of teachers, attitude measurement has been projected to focus on their experiences of teaching science. The measurement has been constructed in a specific way, incorporating elements of cognitive beliefs, affective states, and perceived control [34]. Attitude measurement focused on students has been widely adopted globally. At the primary school level, attitude measurements have been conducted by measuring attitudes towards science, with a focus on assessing interest in science learning, leisure time, and a possible future career in science [35]. A three-dimensional model of science attitudes was used to measure the attitudes of elementary students, focusing on affective feelings about science, behavioural tendencies towards learning science, and cognitive judgements about science [20]. Several studies and global attitude surveys have used the three-dimensional concept and applied it at different educational levels.

The *Trends in International Mathematics and Science Study* (TIMSS) attitude questionnaire, which assesses students in grades 4 and 8, has three components: liking learning science, confidence in science, and the value of science [4]. In TIMSS 2019, the *Students Like Learning Science* scale consisted of nine items that measured students' attitudes towards science and studying science. The results showed a positive relationship between students' attitudes and science achievement. The second, the *Students' Confidence in Science* scale, included nine statements about how well students think they can practice science. The third scale, *Students Value Science* also consisted of nine statements about how well students understand the benefits of learning science subjects [23]. Attitude as measured in the TIMSS study aligns self-concept of expectancy and the intrinsic utility value of science which reflects the interest and importance of an individual position in science [36,37]. The framework of TIMSS assessment is aligned with affective and cognitive dimensions of attitude towards science construct. Liking science and confidence in science express the affective dimensions, whereas the value of science explains the cognitive dimension.

Another global survey of attitudes towards science was carried out by the Programme for International Students Assessments (PISA) among 15-year-old students. Attitude measures use several categories, including science engagement (science career expectation and participation in science activities), motivation for learning science (enjoyment, interest, and instrumental motivation to learn science), and self-efficacy in science [38]. The PISA science attitudes questionnaire was validated with many students from different countries. Overall, the instrument showed good reliability. For validity, a confirmatory factor analysis (CFA) was performed with a good model fit, except for a poor root mean square error of approximation (RMSEA) value which was higher than the range of fit (>0.08) in several countries [39].

The study about comprehensive review in attitude towards science instruments revealed that affective and emotional dimension such as liking science, enjoyment, anxiety, and confidence mostly appear in the existing instruments [13]. The cognitive dimensions of attitude measurement such as value of science was found majority in US and Chinese context. In addition, some attitude towards science construct also involved behavioural tendency which addressed learning process in specific science subject [40]. The behavioural dimension of attitude was found in Behaviors, Related Attitudes, and Intentions toward Science (BRAINS) instruments which focused on the effects of learning science or becoming a scientist in Indonesian context [41]. Despite, the various dimensions were found in existed attitude measurement, the use of affective, cognitive, and behavioural dimension was seemingly appropriate to be put as one integrated attitude towards science construct.

In higher education, the studies of attitude towards science assessment with science, technology, environment, and mathematics (STEM) students focused on the subject matter and learning topic [42]. As students enrolling in science studies tend to show better attitudes towards science rather than non-science students [43], considering students' majors and their subjects will be a great concern for attitudes measurement in higher education. The other attitude studies in other major such as social, language study, psychology, and other non-science major was found to get constructed based on their specific subject matter [44–46]. The framework and measurement properties in different context of attitude assessment was varied but most of them still maintain the cognitive, affective, and behavioural aspects [45].

However, the issue about attitude measurement in higher education was raised due to their psychometric analysis. Many studies conducted content validity with the involvement of experts who check the quality of the items but there is still a lack of construct validity supporting the theoretical framework with empirical evidence. Despite the existence of a number of instruments for measuring attitudes in science, some of them have been found not to meet empirical criteria, so some instruments lack strong validity evaluations [13]. The critical aspects of attitude measurements should follow psychometric properties so that instruments are able to assess the desired skills or traits. Another aspect is the context and the background of the participants, which sometimes affect the adaptability of existing attitude instruments.

2. The present study

This study focused on measuring attitudes towards science in higher education, particularly in science and engineering. In science major, we involved second-year students who enrolled in biology education as science teacher candidates. In the engineering major, second-year students from food engineering were involved in this study. The instrument used to measure attitudes was adapted from several studies and applied to an Indonesian context. We aimed to answer two main research questions.

RQ1. Is the attitude towards science questionnaire valid in a sample of Indonesian university students?

RQ2. Is there any difference between science and engineering students' attitude towards science?

3. Method

3.1. Participants

The study involved 296 students from three universities in Central Java, Indonesia. They were enrolled in science teacher (56.08%) and engineering major (43.92%) undergraduate courses and being selected using cluster random sampling [47]. The participants were predominantly female (84.46%) with mean age as 20.35 years (SD = 1.54). In Indonesia, science teacher candidate and engineering students take science courses such as general biology, physics, and chemistry in the first year of their studies, and later take different courses based on their study program. The second-year students were chosen as a sample because they have already started to take different courses related to their professional development.

3.2. Instrument

We used the Attitude Towards Science Questionnaire (ATSQ) which was adapted from previous studies that have properties suitable to the Indonesian context [12,19,48–50]. The questionnaire used the prominent items from past studies with the rearrangement of some items based on the three-dimensional theoretical construct. Not all items in the previous study were used in this adapted version. Only individual items which showed good psychometric properties and context congruity was chosen for the new construct. There are general criteria when designing the questionnaire to address attitudes towards science including format, wording, and conditional adaptability. We elaborated the items with changes in item sequences by adding or replacing the words to fit the context and the university age group. A total of 27 items were used in the questionnaire and distributed across three dimensions (Fig. 1). Among the three-dimension of attitude towards science framework, the affective dimension was explained by two variables, while the behavioural and cognitive dimension was explained by one variable each.

In affective dimension, we distinguished the positive and negative emotions towards science for the latent variable. The first variable in affective dimension is *Enjoyment and confidence* which represents the positive emotions. This variable consists of 8 items representing liking science, interest, and self-capability in science. The second variable is *Anxiety and difficulty* which consist of 7 items. This variable showed negative emotions in the affective dimension by representing a state of discomfort, fear, and distress about science. In behavioural dimension, there is *Participation in science learning and activity* variable manifested by 8 items. This variable assesses whether students have the tendency to participate in science activities in the classroom or any informal learning about science which represents behavioural dimension. The last latent variable is the *Value of science* which belongs to cognitive dimension. Value of science variable consists of 4 items measuring students' perceptions about science value and benefits in life and society. In developing the questionnaire, two experts checked the suitability of the questionnaire and the language to the context which result in good structure and content quality of the questionnaire.

The scoring type for each item is based on a Likert scale, which indicates how much respondents agree or disagree with each statement. The scale ranges from strongly disagree (1) to strongly agree (5). The questionnaire was originally written in English, then back and forward translation was done into Indonesian language. All items were placed on an online form and sent to the students.

3.3. Data collection and analysis

The participants were voluntarily to fill the questionnaire with confidential identification. To determine the validity of the questionnaire, a confirmatory factor analysis (CFA) with a weighted least square (WLSMV) parameter was conducted to confirm the questionnaire's empirical construct. CFA follows several parameters for defining model fit indexes including the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root means square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). The cut-off value of each parameter followed CFI >0.90, TLI >0.90, RMSEA <0.08, and SRMR <0.06 [25,51].

Rasch analysis was used in addition to construct validity to check the fit of individual items in the questionnaire. The Rasch analysis was used to measure the fit of individual items in the attitude towards science questionnaire with the fit parameter of infit and outfit mean square (MNSQ) ranging from 0.5 to 1.5 [52] and a positive value of point-measure correlation (PTMA). Additional differential item functioning (DIF) was performed to check the questionnaire bias towards the sample group.

The descriptive and comparative analysis was also added to get the students' profile of attitudes towards science and see the difference between science teacher candidates' and engineering students' attitudes. For descriptive and comparison analysis we converted the students' responses (ordinal data) into logit values generated from the Rasch analysis to estimate the students' attitude levels. The logit value represents students' performance which is located at different parts of a single trait [52]. The logit value will convert students' responses to interval data which can be used for descriptive and *t*-test comparison analysis. The analysis process was performed by SPSS, MPLUS, and Winstep programs.

Table 1
The items validity of Attitude Towards Science Questionnaire based on CFA and Rasch analysis.

Items	CFA factor loading	Rasch analysis				
		measure	SE	Infit MNSQ	Outfit MNSQ	PTMA
F1: Enjoyment and confidence (ENJ)						
Item 1	0.88	−0.77	0.12	0.90	0.89	0.86
Item 3	0.74	1.40	0.12	1.29	1.39	0.76
Item 5	0.82	−0.24	0.12	1.00	0.98	0.84
Item 9	0.65	1.65	0.12	1.59	1.92	0.67
Item 12	0.86	−0.18	0.12	0.92	0.89	0.86
Item 20	0.93	−0.64	0.12	0.64	0.62	0.91
Item 21	0.97	−0.74	0.12	0.64	0.62	0.91
Item 26	0.92	−0.48	0.12	0.87	0.68	0.87
F2: Anxiety and difficulty (ANX)						
Item 4	0.82	0.06	0.11	0.98	0.97	0.83
Item 6	0.78	−0.09	0.11	1.10	1.08	0.79
Item 13	0.70	0.26	0.11	1.39	1.38	0.72
Item 16	0.92	−0.17	0.11	0.77	0.77	0.89
Item 17	0.95	−0.16	0.11	0.84	0.81	0.89
Item 18	0.91	0.09	0.11	0.80	0.78	0.88
Item 23	0.83	0.01	0.11	1.07	1.07	0.83
F3: Participation in science learning and activity (PAR)						
Item 7	0.76	0.02	0.11	1.17	1.14	0.79
Item 8	0.71	0.27	0.11	1.34	1.35	0.75
Item 14	0.80	−0.06	0.11	1.01	1.00	0.81
Item 15	0.82	0.35	0.11	0.80	0.82	0.85
Item 22	0.97	−0.14	0.11	0.69	0.67	0.87
Item 24	0.85	0.21	0.11	0.78	0.78	0.82
Item 25	0.77	0.48	0.11	1.14	1.13	0.80
Item 27	0.88	−1.13	0.11	0.98	0.97	0.84
F4: Value of science (SVAL)						
Item 2	0.92	−0.14	0.13	0.99	0.98	0.90
Item 10	0.87	−0.33	0.13	0.85	0.83	0.91
Item 11	0.85	−0.37	0.13	1.04	1.01	0.89
Item 19	0.91	−0.10	0.13	1.06	1.01	0.89
Mean	0.84	−0.03	0.12	0.99	0.98	0.84
SD	0.08	0.58	0.01	0.23	0.28	0.06

4. Results

4.1. The instrument's validity

The result of validity analysis determines the questionnaire quality based on the theoretical model and individual items' parameter (Table 1). CFA showed acceptable result for ATSQ with four latent variables, CMIN/df = 2.61, CFI = 0.98, TLI = 0.98, RMSEA = 0.07, and SRMR = 0.04. The factor loading from CFA revealed a similar value across the variables with the mean loading as 0.84. This value represents the compatibility of items to explain the constructed variable. Indeed, all items of the questionnaire were able to measure attitudes towards science in each latent variable.

Rasch analysis showed good infit ($M_{infit} = 0.99$) and outfit ($M_{outfit} = 0.98$) MNSQ value meaning that the items in the questionnaire will measure students' attitudes towards science correctly. In the case of item 9, the infit and outfit MNSQ are above 1.5. This item will still be considered an acceptable item as it has positive PTMA correlation. Thus, the exclusion of this item from the questionnaire would disrupt the theoretical aspects of the measurement. Regarding the items' parametric properties, we can see that the logit measure of overall items was close to 0 ($M_{logit} = -0.03$, SD = 0.58). It can be interpreted that measured items were categorized as a moderate level. The most difficult item of the questionnaire was item 9, where students gave mostly low score in their response (logit measure = 1.65). The easiest item was item 27 (logit measure = - 1.13), for which students gave mostly confidently high score. In addition, Rasch analysis also computed the dimensionality, resulting the average variance explained by the measure of ATSQ variables is higher than the critical point (≥30%), suggesting that the questionnaire measures only the dimension of attitude [53].

Additional different items functioning (DIF) measurement with Rasch analysis was performed to measure the questionnaire invariance between groups. DIF analysis measure whether the questionnaire items behave differently toward a specific group. In this study, we measure DIF between science teacher candidate and engineering group. The estimation for DIF analysis follows significant probability ($p < 0.05$) with high size estimation (≥0.64) [52]. Significant result and high size estimation indicate that DIF is presented in the item. In contrast, non-significant with low size estimation indicate no DIF. Furthermore, significant result with low size also interprets as negligible and perform no bias towards different group. We measure DIF in science and engineering groups showing non-significant result for each item in ATSQ ($p > 0.05$) with low size contrast (Fig. 2), except item 8 ($p = 0.01$) and item 16 ($p = 0.03$). Both items 8 and 16 show low DIF size (<0.64) which can be interpreted as performing negligible invariant.

Based on the CFA and Rasch analysis, ATSQ was considered valid and able to measure students' attitudes towards science correctly. DIF analysis also revealed that the questionnaire has no bias towards a specific group. Due to this result, ATSQ can be used for further assessment and evaluation of students' attitudes towards science.

4.2. Reliability

The reliability analysis was performed to check the questionnaire consistency towards the participants response, with the criteria

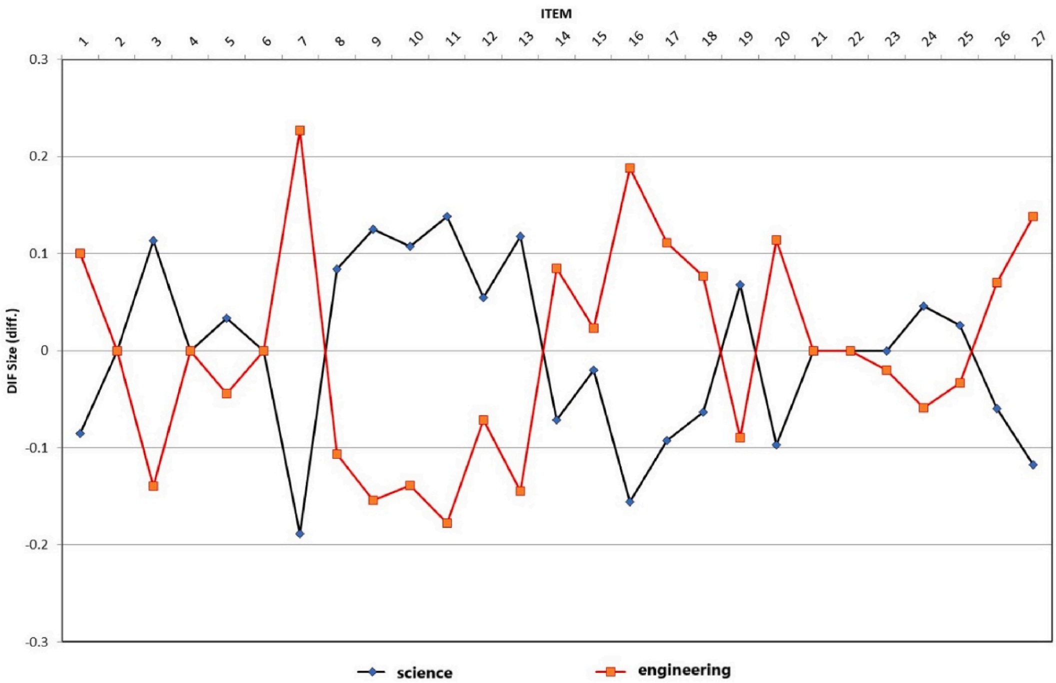

Fig. 2. DIF analysis in the science teacher candidate and engineering group.

for reliable coefficient following a range value of ($r > 0.7$) for an acceptable result [54]. The reliability analysis showed good result for ATSQ, meaning that the items of the questionnaire consistently measured students' attitudes towards science (Table 2). However, the anxiety and difficulty variable showed low item reliability, suggesting that some items of the variable behave differently than others. On the other hand, the other reliability parameters showed good coefficient, which can be considered an acceptable result for the anxiety and difficulty variable.

4.3. The profile of students' attitude towards science in science teacher candidate and engineering major

The distribution of students' attitudes towards science was projected by analysing the persons' logit value, which indicated the position of students' level based on the measured items. We compared the attitude levels of science teacher candidates and engineering students for each variable (Fig. 3). In the *Enjoyment and confidence* category, there is no difference between science teacher candidates and engineering students' attitude levels ($t = 1.52, p > 0.01, d = 0.18$). A similar result also was found in the *Anxiety and difficulty* ($t = 1.86, p > 0.01, d = 0.22$), the *Participation in science learning and activities* ($t = 1.93, p > 0.01, d = 0.23$), and the *Value of science* category ($t = 0.62, p > 0.01, d = 0.08$). The total attitude towards science in both groups also did not show any difference ($t = 1.94, p > 0.01, d = 0.23$), meaning that both science teacher candidates and engineering students' have similar attitudes towards science. The overall students' attitude level in the two groups reached the mean score of 0.54 logit (SD = 1.20) which is close to 0 logit representing a moderate level of attitude. In the four categories of attitudes towards science, the *Value of science* showed the highest logit value ($M_{logit} = 2.96$, SD = 3.73) followed by *Enjoyment* ($M_{logit} = 1.54$, SD = 3.07) and *Participation in science learning and activities* ($M_{logit} = 1.16$, SD = 2.68), while the lowest logit value goes to the *Anxiety* category ($M_{logit} = 0.22$, SD = 2.78).

The relationship between the attitude variables was examined by calculating the correlations (Fig. 4). In the case of science teacher candidates, there is a strong positive correlation between students' enjoyment and their willingness to participate in science learning and activities as well as their perception of the value of science. In contrast, the anxiety is not significantly correlated with other variables, meaning that the increase in anxiety is not related to students' participation in science learning and activities, and their perceptions about the value of science. For engineering students, a different pattern was found since all attitude variables significantly positively correlate with the others. A strong correlation is found between enjoyment and participation in science learning and activities and the value of science, while anxiety shows moderate correlations with the other variables.

5. Discussion

Construct validity with CFA showed an acceptable model fit, indicating that the instrument has a good theoretical foundation with four latent variables. Rasch analysis is also considered as one of the powerful measurements for qualifying assessment tools with some functions in item's positioning [55]. It can determine the quality of the measurement by calculating the fit measure based on the item's level and person's responses. The Indonesian version of ATSQ showed a prominent fit value for each item and acceptable reliability from the Rasch model analysis, indicating that the questionnaire measured the trait correctly and consistently. Among the four variables of ATSQ, the ANX variable shows lower items reliability while the other reliability parameters are high within the university sample which concludes an acceptable standard. Since the ANX variable shows negative aspects of attitudes, this may explain why the psychometric properties of this variable differ from the other variables which represent positive attitudes. Hence, the ATSQ has overall good psychometric properties confirming that the questionnaire is reliable and valid for the assessment of attitude towards science.

In this study, participants from science teacher candidate and engineering majors showed similar tendencies in attitudes towards science. Similar responses were obtained for all variables, which means that there is no significant difference in any of the aspects of attitudes towards science. Both groups showed high responses in the SVAL variable meaning that they have high beliefs about the benefit and value of science. It represents their understanding that science is important in the communities which can be a potential factor in progressing their science-related studies. In the other categories, majority of students in science teacher candidates and engineering majors have a positive response in enjoyment and participation in science learning and activities. Bivariate correlation analysis also revealed that ENJ has a higher correlation with PAR. In this case, we can see that high enjoyment in science is connected to the tendency to in the participating science activities and the learning process. Supportive environment and cultural perspective are believed to be able to influence persons' attitude [56,57]. Several studies also reported that the attitudes and students' enjoyment in learning is affected by the learning activities [58–60]. It implies that students with a high willingness to participate in science learning and activities are those who like science and showed a positive attitude towards science.

In the ANX category, students had lower scores compared to the other variables. However, the ANX mean score of science teacher candidate was higher than 0 logit indicating a moderate level of anxiety and difficulty. In contrast, the engineering majors' mean logit

Table 2
The reliability of the Attitude Towards Science Questionnaire.

Variables	Cronbach alpha	McDonald omega	Persons' reliability	Item's reliability
Enjoyment and confidence	.94	.94	.92	.98
Anxiety and difficulty	.93	.93	.91	.38
Participation in science learning and activity	.93	.93	.91	.94
Value of science	.92	.92	.88	.77
Total	.95	.95	.93	.97

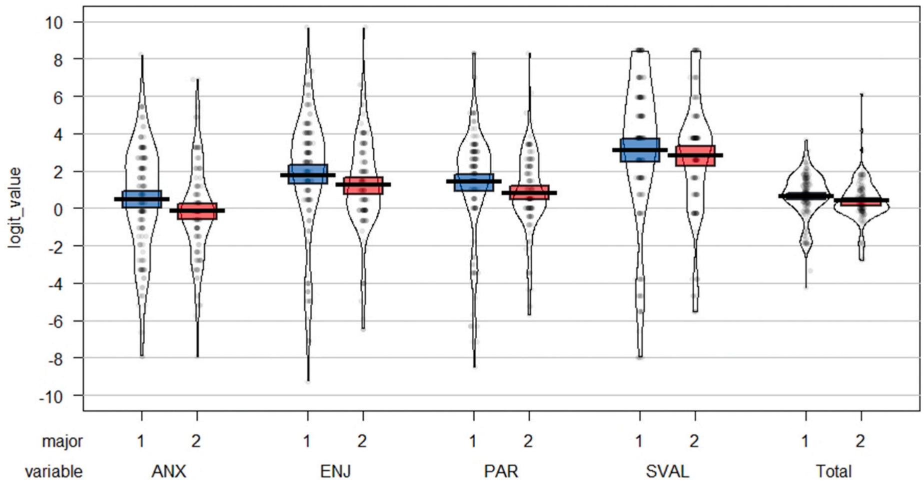

Fig. 3. Distribution of level students' attitudes towards science (1 = science teacher candidate, 2 = engineering major).
ANX: Anxiety and difficulty, ENJ: Enjoyment and confidence, PAR: Participation in science learning and activity, SVAL: Value of science.

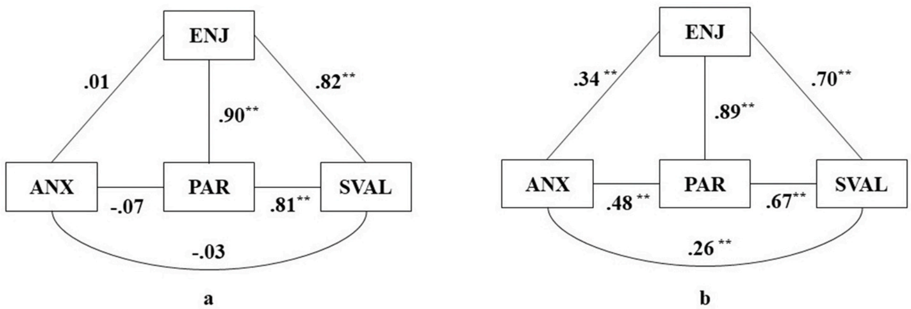

Fig. 4. Correlations between the variables of attitudes towards science among the science teacher candidates and engineering students.
a = science teacher major, b = engineering major; ENJ: Enjoyment and confidence, ANX: Anxiety and difficulty, PAR: Participation in science learning and activity, SVAL: Value of science.

lower than 0. In this case, engineering students had fewer negative feelings towards science and less difficulty with science in their current state. In the case of the science teacher major, we found no correlation between ANX and other variables, while in the engineering major, there is a weak significant positive correlation. This difference can be interpreted that the level of anxiety and difficulty in science students is independent and not associated with the other variables whereas in engineering majors all the variables are connected. The difference is potentially caused by the learning diversity and environment, as the two groups have different curricula and materials, which require different learning approaches [61]. No correlation between ANX and other variables in science teacher candidate major implies that the situational factor during their studies may stimulate their negative feelings and anxiety level [62]. This is supported by other studies explain that cultural and situational influences contribute to the development of anxiety [63]. Some study also reported that students in science field has higher anxiety compared to the other field which can affect attitude and decrease enjoyment level [64]. It is supported by other studies that revealed that anxiety has a low and negative correlation to other factors such as interest in learning and confidence [65].

Looking at the results of this research, it can be argued that science teacher candidates and engineering students generally have a positive attitude towards science. Both groups gave a similar response in the attitude categories, but the correlation patterns for the ANX variable are different which raise protentional analysis regarding the situational and sociocultural state of the students. It is worth including additional factors to explain these differences with an increased sample size. Since this study was limited to second-year science teacher candidates and engineering students, longitudinal studies are also needed to reveal the development of attitudes over the education period at different levels. Another limitation arose due to the lack of information about qualitative analysis to define the quality of the items. Therefore, additional qualitative analysis, such as construct mapping, interviews, and expert analysis, could be included in future research on attitudes towards science assessment. It also recommends testing the questionnaire with a different sample. Moreover, even if the result of the attitude measurement in this study showed prominent findings, different evidence may be found with the involvement of other samples and study levels. It is important to confirm the empirical evidence of the validation of the ATSQ and to provide more information on attitudes towards science with various context.

6. Conclusion

The Indonesian version of ATSQ showed good empirical properties so it can be shown to measure the university students' attitudes towards science correctly in the Indonesian context. The attitude measurement among science teacher candidates and engineering students using ATSQ revealed that both groups showed moderate levels of attitudes with higher responses in the value of science variable, followed by enjoyment, anxiety and difficulty, and participation in science learning and activities. The present research could be a good starting point for further studies to confirm the empirical characteristics of the ATSQ at different levels of education and in different context. The developed questionnaire could also be used in research aimed at exploring the factors that shape attitudes towards science.

Ethic statement

Participants and the university research committee both gave their consent by ethical standards (Approval committee: The Institutional Review Board of the Doctoral School of Education, University of Szeged. Approval Number: 08/2023).

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Author contribution statement

Azizul Ghofar Candra Wicaksono: conceived and designed the experiments; performed the experiments; analyzed and interpreted the data; contributed reagents, materials, analysis tools or data; wrote the paper. Erzsébet Korom: contributed reagents, materials, analysis tools or data; wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare no competing interests or personal relationships that could have appeared to influence the work reported in this paper

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e20023.

References

[1] R. Krishnakumar, K.M. Rajesh, Attitude of teachers' of higher education towards e-learning, J. Educ. Pract. 2 (4) (2011) 41–47 [Online]. Available: https://www.iiste.org/Journals/index.php/JEP/issue/view/34.
[2] Pddikti, Statistik Pendidikan Tinggi 2020, Pangkalan Data Pendidikan Tinggi, Jakarta, 2020.
[3] J.J. Doll, Z. Eslami, L. Walters, Understanding why students drop out of high school, according to their own reports, Sage Open 3 (4) (Jan. 2013), 215824401350383, https://doi.org/10.1177/2158244013503834.
[4] T.J. Smith, S.L. Pasero, C.M. McKenna, Gender effects on student attitude toward science, Bull. Sci. Technol. Soc. 34 (1–2) (2014) 7–12, https://doi.org/10.1177/0270467614542806. Feb.
[5] Y. Lee, J. Choi, A review of online course dropout research: implications for practice and future research, Educ. Technol. Res. Dev. 59 (5) (Oct. 2011) 593–618, https://doi.org/10.1007/s11423-010-9177-y.
[6] J. Ferrer, A. Ringer, K. Saville, M.A. Parris, K. Kashi, Students' motivation and engagement in higher education: the importance of attitude to online learning, High Educ. 83 (2) (Feb. 2022) 317–338, https://doi.org/10.1007/s10734-020-00657-5.
[7] E. Peteros, D. Columna, J.O. Etcuban, P. Almerino Jr., J.G. Almerino, Attitude and academic achievement of high school students in mathematics under the conditional cash transfer program, Int. Electron. J. Math. Educ. 14 (3) (May 2019), https://doi.org/10.29333/iejme/5770.
[8] X. Chen, The effects of individual- and class-level achievement on attitudes towards mathematics: an analysis of Hong Kong students using TIMSS 2019, Stud. Educ. Eval. 72 (Mar. 2022), 101113, https://doi.org/10.1016/j.stueduc.2021.101113.
[9] C.O. Nja, R.E. Orim, H.A. Neji, J.O. Ukwetang, U.E. Uwe, M.A. Ideba, Students' attitude and academic achievement in a flipped classroom, Heliyon 8 (1) (Jan. 2022), e08792, https://doi.org/10.1016/j.heliyon.2022.e08792.

[10] T.J. Smith, D.A. Walker, H. Chen, Z. Hong, Students' sense of school belonging and attitude towards science: a cross-cultural examination, Int. J. Sci. Math. Educ. 18 (5) (Jun. 2020) 855–867, https://doi.org/10.1007/s10763-019-10002-7.
[11] J. Osborne, S. Simon, S. Collins, Attitudes towards science: a review of the literature and its implications, Int. J. Sci. Educ. 25 (9) (Sep. 2003) 1049–1079, https://doi.org/10.1080/0950069032000032199.
[12] P. Kind, K. Jones, P. Barmby, Developing attitudes towards science measures, Int. J. Sci. Educ. 29 (7) (Jun. 2007) 871–893, https://doi.org/10.1080/09500690600909091.
[13] R.B. Toma, N.G. Lederman, A comprehensive review of instruments measuring attitudes toward science, Res. Sci. Educ. 52 (2) (Apr. 2022) 567–582, https://doi.org/10.1007/s11165-020-09967-1.
[14] R.M. Perloff, The Dynamics of Persuasion: Communication and Attitudes in the Twenty-First Century, Routledge, London, 2016.
[15] P. Potvin, A. Hasni, Interest, motivation and attitude towards science and technology at K-12 levels: a systematic review of 12 years of educational research, Stud. Sci. Educ. 50 (1) (Jan. 2014) 85–129, https://doi.org/10.1080/03057267.2014.881626.
[16] H. Dismore, R. Bailey, Fun and enjoyment in physical education: young people's attitudes, Res. Pap. Educ. 26 (4) (Dec. 2011) 499–516, https://doi.org/10.1080/02671522.2010.484866.
[17] M.S. Khine, Attitude Measurements in Science Education: Classic and Contemporary Approaches, Charlotte: Information Age Publishing, INC., 2015.
[18] N. Reid, Thoughts on attitude measurement, Res. Sci. Technol. Educ. 24 (1) (May 2006) 3–27, https://doi.org/10.1080/02635140500485332.
[19] S.I. van Aalderen-Smeets, J.H. Walma van der Molen, L.J.F. Asma, Primary teachers' attitudes toward science: a new theoretical framework, Sci. Educ. 96 (1) (Jan. 2012) 158–182, https://doi.org/10.1002/sce.20467.
[20] D. Zhang, T. Campbell, The psychometric evaluation of a three-dimension elementary science attitude survey, J. Sci. Teach. Educ. 22 (7) (Oct. 2011) 595–612, https://doi.org/10.1007/s10972-010-9202-3.
[21] L. Schaverien, M. Cosgrove, A biological basis for generative learning in technology-and-science Part II: implications for technology-and-science education, Int. J. Sci. Educ. 22 (1) (Jan. 2000) 13–35, https://doi.org/10.1080/095006900289985.
[22] Z.H. Wan, J.C.K. Lee, Hong Kong secondary school students' attitudes towards science: a study of structural models and gender differences, Int. J. Sci. Educ. 39 (5) (Mar. 2017) 507–527, https://doi.org/10.1080/09500693.2017.1292015.
[23] I.V.S. Mullis, M.O. Martin, P. Foy, D.L. Kelly, B. Fishbein, TIMSS 2019 International Results in Mathematics and Science, Boston, 2020 [Online]. Available: https://timssandpirls.bc.edu/timss2019/international-results/.
[24] K. Reynolds, L. Khorramdel, M. von Davier, Can students' attitudes towards mathematics and science be compared across countries? Evidence from measurement invariance modeling in TIMSS 2019, Stud. Educ. Eval. 74 (Sep. 2022), 101169, https://doi.org/10.1016/j.stueduc.2022.101169.
[25] L. Hu, P.M. Bentler, Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives, Struct. Equ. Model. A Multidiscip. J. 6 (1) (Jan. 1999) 1–55, https://doi.org/10.1080/10705519909540118.
[26] R. Pekrun, The control-value theory of achievement emotions: assumptions, corollaries, and implications for educational research and practice, Educ. Psychol. Rev. 18 (4) (2006) 315–341, https://doi.org/10.1007/s10648-006-9029-9. Nov.
[27] F.C. Mercan, Control-value theory and enjoyment of science: a cross-national investigation with 15-year-olds using PISA 2006 data, Learn. Indiv Differ 80 (May 2020), 101889, https://doi.org/10.1016/j.lindif.2020.101889.
[28] F.D. Davis, R.P. Bagozzi, P.R. Warshaw, Extrinsic and intrinsic motivation to use computers in the Workplace1, J. Appl. Soc. Psychol. 22 (14) (1992) 1111–1132, https://doi.org/10.1111/j.1559-1816.1992.tb00945.x. Jul.
[29] T. Teo, J. Noyes, An assessment of the influence of perceived enjoyment and attitude on the intention to use technology among pre-service teachers: a structural equation modeling approach, Comput. Educ. 57 (2) (Sep. 2011) 1645–1653, https://doi.org/10.1016/j.compedu.2011.03.002.
[30] R. Christensen, G. Knezek, Indicators of middle school students' mathematics enjoyment and confidence, Sch. Sci. Math. 120 (8) (Dec. 2020) 491–503, https://doi.org/10.1111/ssm.12439.
[31] X. Ma, J. Xu, The causal ordering of mathematics anxiety and mathematics achievement: a longitudinal panel analysis, J. Adolesc. 27 (2) (Apr. 2004) 165–179, https://doi.org/10.1016/j.adolescence.2003.11.003.
[32] M.H. Ashcraft, J.A. Krause, D.R. Hopko, Is Math Anxiety a Mathematical Learning Disability? Why Is Math So Hard for Some Children? the Nature and Origins of Mathematical Learning Difficulties and Disabilities, D. B. Berc. Paul H. Brookes Publishing Co., 2007.
[33] D.J. Mueller, Measuring Social Attitudes, Teacher College Press, New York, 1986.
[34] S. van Aalderen-Smeets, J. Walma van der Molen, Measuring primary teachers' attitudes toward teaching science: development of the dimensions of attitude toward science (DAS) instrument, Int. J. Sci. Educ. 35 (4) (Mar. 2013) 577–600, https://doi.org/10.1080/09500693.2012.755576.
[35] B.J. Fraser, S.U. Lee, Use of test of science related attitudes (TOSRA) in Korea, in: Attitude Measurements in Science Education: Classic and Contemporary Approaches, Information Age Publishing, INC., Charlotte, 2015, pp. 293–308.
[36] N. Berger, E. Mackenzie, K. Holmes, Positive attitudes towards mathematics and science are mutually beneficial for student achievement: a latent profile analysis of TIMSS 2015, Aust. Educ. Res. 47 (3) (2020) 409–444, https://doi.org/10.1007/s13384-020-00379-8. Jul.
[37] J. Guo, H.W. Marsh, P.D. Parker, A.J.S. Morin, A.S. Yeung, Expectancy-value in mathematics, gender and socioeconomic background as predictors of achievement and aspirations: a multi-cohort study, Learn. Indiv Differ 37 (Jan. 2015) 161–168, https://doi.org/10.1016/j.lindif.2015.01.008.
[38] OECD, PISA 2015 Results, ume V, OECD, 2017.
[39] OECD, PISA 2006 Technical Report, Paris, 2006 [Online]. Available: https://www.oecd.org/education/school/programmeforinternationalstudentassessmentpisa/pisa2006technicalreport.htm.
[40] D. Cheung, Students' attitudes toward chemistry lessons: the interaction effect between grade level and gender, Res. Sci. Educ. 39 (1) (Jan. 2009) 75–91, https://doi.org/10.1007/s11165-007-9075-4.
[41] R.Q. Aini, A. Rachmatullah, M. Ha, Indonesian primary school and middle school students' attitudes toward science: focus on gender and academic level, J. Baltic Sci. Educ. 18 (5) (Oct. 2019) 654–667, https://doi.org/10.33225/jbse/19.18.654.
[42] K.-H. Tseng, C.-C. Chang, S.-J. Lou, W.-P. Chen, Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment, Int. J. Technol. Des. Educ. 23 (1) (2013) 87–102, https://doi.org/10.1007/s10798-011-9160-x. Feb.
[43] L. Gogolin, F. Swartz, A quantitative and qualitative inquiry into the attitudes toward science of nonscience college students, J. Res. Sci. Teach. 29 (5) (May 1992) 487–504, https://doi.org/10.1002/tea.3660290505.
[44] L.M. Schaefer, et al., Development and validation of the sociocultural attitudes towards appearance questionnaire-4 (SATAQ-4), Psychol. Assess. 27 (1) (Mar. 2015) 54–67, https://doi.org/10.1037/a0037917.
[45] M.J. Zainol Abidin, M. Pour-Mohammadi, H. Alzwari, EFL students' attitudes towards learning English language: the case of Libyan secondary school students, Asian Soc. Sci. 8 (2) (2012), https://doi.org/10.5539/ass.v8n2p119. Jan.
[46] H.-X. Bo, et al., Posttraumatic stress symptoms and attitude toward crisis mental health services among clinically stable patients with COVID-19 in China, Psychol. Med. 51 (6) (Apr. 2021) 1052–1053, https://doi.org/10.1017/S0033291720000999.
[47] J.A. Gliner, G.A. Morgan, N.L. Leech, Research Methods in Applied Settings: an Integrated Approach to Design and Analysis, Routledge, 2016.
[48] J.L. Wendt, A. Rockinson-Szapkiw, A psychometric evaluation of the English version of the dimensions of attitudes toward science instrument with a U.S. population of elementary educators, Teach. Teach. Educ. 70 (Feb. 2018) 24–33, https://doi.org/10.1016/j.tate.2017.11.009.
[49] L.J. Francis, J.E. Greer, Measuring attitude towards science among secondary school students: the affective domain, Res. Sci. Technol. Educ. 17 (2) (Nov. 1999) 219–226, https://doi.org/10.1080/0263514990170207.
[50] R. Summers, F. Abd-El-Khalick, Development and validation of an instrument to assess student attitudes toward science across grades 5 through 10, J. Res. Sci. Teach. 55 (2) (Feb. 2018) 172–205, https://doi.org/10.1002/tea.21416.
[51] H.W. Marsh, K.-T. Hau, Z. Wen, Search of Golden Rules: Comment on Hypothesis-Testing Approaches to Setting Cutoff Values for Fit Indexes and Dangers in Overgeneralizing Hu and Bentler's (1999) Findings," Struct. Equ. Model. A Multidiscip. J. 11 (3) (2004) 320–341, https://doi.org/10.1207/s15328007sem1103_2. Jul.

[52] W.J. Boone, J.R. Staver, M.S. Yale, Rasch Analysis in the Human Sciences, Springer Science & Business Media, 2014.
[53] J.M. Linacre, A User's Guide to Winsteps Ministeps: Rasch-Model Computer Programs, Electronic Publication, Chicago: IL, 2006.
[54] J.A. Gliner, G.A. Morgan, N. Leech, Research Method in Applied Settings: an Integrated Approach to Design and Analysis, Routledge, Taylor and Francis, New York, 2017.
[55] W.J. Boone, Rasch analysis for instrument development: why, when, and how?, Dec, CBE-Life Sci. Educ. 15 (4) (2016) rm4, https://doi.org/10.1187/cbe.16-04-0148.
[56] F. Almasri, G.I. Hewapathirana, F. Ghaddar, N. Lee, B. Ibrahim, Measuring attitudes towards biology major and non-major: effect of students' gender, group composition, and learning environment, PLoS One 16 (5) (May 2021), e0251453, https://doi.org/10.1371/journal.pone.0251453.
[57] L.B. Krogh, P.V. Thomsen, Studying students' attitudes towards science from a cultural perspective but with a quantitative methodology: border crossing into the physics classroom, Int. J. Sci. Educ. 27 (3) (Jan. 2005) 281–302, https://doi.org/10.1080/09500690412331314469.
[58] C.-Y. Chao, Y.-T. Chen, K.-Y. Chuang, Exploring students' learning attitude and achievement in flipped learning supported computer aided design curriculum: a study in high school engineering education, Jul, Comput. Appl. Eng. Educ. 23 (4) (2015) 514–526, https://doi.org/10.1002/cae.21622.
[59] M.C. Ralph, B. Schneider, D.R. Benson, D. Ward, Separated by spaces: undergraduate students re-sort along attitude divides when choosing whether to learn in spaces designed for active learning, Aug, Act. Learn. High. Educ. (2022), 146978742211188, https://doi.org/10.1177/14697874221118866.
[60] M. Vandecandelaere, S. Speybroeck, G. Vanlaar, B. De Fraine, J. Van Damme, Learning environment and students' mathematics attitude, Stud. Educ. Eval. 38 (3–4) (Sep. 2012) 107–120, https://doi.org/10.1016/j.stueduc.2012.09.001.
[61] W.D. Callister, D.G. Rethwisch, Fundamentals of Materials Science and Engineering: an Integrated Approach, John Wiley & Sons, 2020.
[62] D. Rozgonjuk, T. Kraav, K. Mikkor, K. Orav-Puurand, K. Täht, Mathematics anxiety among STEM and social sciences students: the roles of mathematics self-efficacy, and deep and surface approach to learning, Dec, Int. J. STEM Educ. 7 (1) (2020) 46, https://doi.org/10.1186/s40594-020-00246-z.
[63] M.S.B. Yusoff, A.F. Abdul Rahim, A.A. Baba, S.B. Ismail, M.N. Mat Pa, A.R. Esa, Prevalence and associated factors of stress, anxiety and depression among prospective medical students, Asian J. Psychiatr. 6 (2) (Apr. 2013) 128–133, https://doi.org/10.1016/j.ajp.2012.09.012.
[64] N.H. Bui, M.A. Alfaro, Statistics anxiety and science attitude: age, gender, and ethnicity factor, Coll. Student J. 45 (3) (2011) 573–585 [Online]. Available: https://eds.s.ebscohost.com/eds/pdfviewer/pdfviewer?vid=0&sid=67291ccb-566c-407d-8e80-0779bbb40f4d%40redis.
[65] J.-C. Hong, M.-Y. Hwang, K.-H. Tai, C.-R. Tsai, An exploration of students' science learning interest related to their cognitive anxiety, cognitive load, self-confidence and learning progress using inquiry-based learning with an iPad, Res. Sci. Educ. 47 (6) (Dec. 2017) 1193–1212, https://doi.org/10.1007/s11165-016-9541-y.