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Developing an instruments to measure prospective teacher beliefs about mathematical problem-solving using the Rasch model

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Abstract

Beliefs in solving mathematical problems become the basis for action, the basis for change, and the basis for learning mathematics. This research describes the development of an instrument for measuring prospective teachers beliefs in solving mathematical problems. One hundred sixty prospective teachers' with experience in problem-solving and learning mathematics became research respondents. The research data was analysed using the Rasch model. The results of the data analysis show that the instrument developed is considered reliable and valid. Fifty-five items can be used to measure prospective teachers' beliefs about solving mathematical problems. The instruments that have been developed can be used as initial assessments in implementing problem-based learning to help students develop problem-solving skills to face challenges in real life.

Keywords: beliefs; problem-solving; measure; Rasch model

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Introduction

Mathematical problems must be able to be solved within the framework of the maturation process that must be gone through and is a means of self-maturation to ensure one's existence both as an individual and as part of one's environment (Bal, 2015; Memnun et al., 2012; Muhtarom et al., 2020; Siswono et al., 2019). The ability to solve problems is an essential skill that a person must have. To solve mathematical problems, a person tries to direct his mind to recall and utilize mathematical procedures appropriate to the problem (Muhtarom et al., 2019; Siswono et al., 2019). Through mathematical problem solving, students are directed to develop their abilities, including building new mathematical knowledge, solving problems in various contexts related to mathematics, applying the necessary strategies, and reflecting on the mathematical solving process (Arikan, 2016; Harisman et al., 2019; Mkomange et al., 2012).

Positive beliefs in solving mathematical problems are the basis for action, change, and learning mathematics (Muhtarom et al., 2020). This is due to the benefits that can be obtained when problem-solving involves thought processes and self-regulation abilities, thereby enabling the development of a strong understanding and belief in problems accompanied by logical reasons. Beliefs in solving mathematical problems influence mathematics achievement, for example, the problem's difficulty level, the formula to be used, and the decision to recheck the solution (Siswono et al., 2017). Beliefs are cognitive and affective constructs important for the problem-solving learning process (Bal, 2015; Ozturk & Guven, 2016).

Beliefs about mathematics directly influence students' mathematical problem-solving performance. Teaching and gender do not affect the beliefs in problem-solving of prospective mathematics teachers (Memnun et al., 2012). Furthermore, Mkomange et al. (2012) concluded that most future mathematics teachers have positive beliefs about the importance of understanding mathematical problems, ways of solving problems, and learning mathematics that emphasizes contemporary principles. Ozturk & Guven (2016) research concluded that beliefs influence problem-solving. Students who believe solving problems takes a short time can solve them by memorizing the rules. When faced with a more challenging task, students believe in solving the problem as quickly as possible within the allotted time. They assume they will solve the problem soon if they have the ability.

It is essential to measure beliefs in problem-solving. Beliefs in problem-solving can be measured using various techniques such as questionnaires, interviews, and observations (Dorimana et al., 2021; Prendergast et al., 2018; Sağlam & Dost, 2014; Siswono et al., 2016, 2019; Stage & Kloosterman, 1992). Several questions can be used to explore mathematics teachers' problem-solving beliefs (Siswono et al., 2016). Another study using a mixed methods approach with 36 respondents showed that most respondents indicated a positive attitude towards the progress of problem solving in mathematics classes (Dorimana et al., 2021). Sağlam's research was conducted on 413 respondents using the Beliefs about Mathematical Problem Solving instrument developed by Kloosterman and Stage and adapted into Turkish by Haciomeroglu (Sağlam & Dost, 2014). However, the studies above still carried out measurements using classical test theory. Classical test theory has weaknesses due to its dependence on samples and instrument items. As a result, if the measurement instrument is carried out on respondents with low ability, the level of difficulty of the instrument items will be high. Item response theory, whose main component is Rasch modeling, has advantages compared to classical test theory (Rahim & Haryanto, 2021). One of these advantages is that the probability of the subject answering an item correctly depends on the subject's skills and the characteristics of the item (Adi et al., 2022). The Rasch model in analyzing instrument validity can be carried out from several aspects so that the resulting instrument can be more reliable (Andrich & Marais, 2019; Atikah et al., 2022; Indihadi et al., 2022; Saidi & Siew, 2019). Validity analysis using the Rasch model can be better because of its consistency (Sharif et al., 2019; Sumintono, 2018). Another advantage of Rasch modeling is that three reliabilities are obtained, namely person reliability, item reliability, and Cronbach's alpha (Sumintono & Widhiarso, 2015). The Rasch model can show instrument items that are difficult for respondents to agree on and compare the respondent's abilities. Analysis of instrument items related to the respondent's abilities is beneficial in preparing instruments to cover the aspects to be measured (Kaspersen et al., 2017; Muntazhimah & Wahyuni, 2022; Sharif et al., 2019; Sumintono & Widhiarso, 2014). Therefore, this research uses Rasch modeling to examine the reliability and validity of belief instruments in problem solving for prospective mathematics teachers.

Methods

This research is part of research developing an assessment of problem-solving beliefs of prospective mathematics teachers'. The respondents for this research were 160, selected using the random sampling method. Respondents are sixth semester students who have experience in solving mathematical problems and have taken courses in mathematics learning strategies

Table 1. Questionnaire grid for beliefs in problem-solving

Descriptor	Positive Items	Negative Items
Beliefs about the time needed to solve the problem	1, 6, 11	16, 21, 26
Steps in solving mathematical problems	2, 7, 12, 27	17, 22, 32, 33
The relationship between mathematical concepts in solving mathematical problems	3, 13, 23, 28	8, 18, 31, 34
Beliefs about various ways of solving mathematical problems	9, 14, 24	4, 19, 29
Exercises to improve mathematical problem-solving abilities	5, 25, 30	10, 15, 20
Problem-solving learning objectives	36, 51	41
Views on mathematics	40, 50	35, 45, 55
Questions asked in problem-solving learning	57	37
The role of students in problem-solving learning	47, 49, 53, 59	39, 43, 46, 56
The role of the teacher in problem-solving learning	44, 52, 60, 58	38, 42, 54, 48

The development research used is design research and development study type. The emphasis of this type of research is on development with iterative cycles using formative evaluation. The stage consists of three phases: initial investigation, prototype phase, and assessment (Nieveen & Folmer, 2013; van den Akker et al., 2012). In the initial investigation phase, literature studies, respondent observations, and definition of the concept of problem-solving beliefs were carried out. In the prototype phase, researchers designed a questionnaire including a grid and questionnaire instrument for mathematical problem solving beliefs. The instrument was developed by researchers by considering indicators of problem-solving beliefs. In detail, the grid for developing beliefs instruments in solving mathematical problems is presented in Table 1. Furthermore, expert validation and trial testing of the problem-solving beliefs questionnaire were carried out in the assessment phase of research respondents.

Respondents' answers were measured using a Likert scale without providing a midpoint or neutral point on the scale. This was done to ensure that respondents responded to the problem-solving beliefs questionnaire. The research results were analyzed using Rasch modeling via Winsteps software version 3.73. The output used for data analysis is testing the reliability of the instrument using summary statistics, testing the validity of instrument items using output item unidimensionality, output item fit order, using a rating (partial-credit) scale with the criterion that if all ratings have a peak point then the instrument has validity (Huei et al., 2020; Saidi & Siew, 2019; Sumintono & Widhiarso, 2015), and testing instrument items that were difficult and easy for respondents to agree with.

Results

Instrument reliability

Figure 1 provides overall information about the quality of respondents, the quality of the instrument, and the interaction between person and item. Person measure = 0.36 shows respondents' mean score in the instrument of prospective teacher students' beliefs in solving mathematical problems. An average value more significant than the logit value of 0.00 indicates a tendency for respondents to answer more in agreement with statements in various items (Sumintono & Widhiarso, 2014). Cronbach's alpha value = 0.70 is located in the interval 0.70-0.80, which is considered good. Cronbach's alpha value measures reliability, namely the interaction between the person and the item. The value of person reliability = 0.67, which is classified as sufficient, and the value of item reliability = 0.99, which is classified as unique, so it can be concluded that the consistency of the answers from respondents is sufficient, but the quality of the items in the prospective teachers' belief instrument is categorized as unique. This shows that the instrument of prospective teachers' beliefs in solving mathematical problems will provide relatively stable results if used by other researchers.

The average INFIT MNSQ and OUTFIT MNSQ for the person table are 1.01 and 1.03, respectively. The ideal value is 1.00 (the closer to 1.00, the better). The average values for INFIT ZSTD and OUTFIT ZSTD are 0.00 and 0.10, respectively. The ideal value is 0.00 (the closer to 0.00, the better). Likewise, for the item table, the average values obtained for INFIT MNSQ and OUTFIT MNSQ are 1.03 and 1.03, respectively. The ideal value is 1.00 (the closer to 1.00, the better). The average values for INFIT ZSTD and OUTFIT ZSTD are 0.20 and 0.20, respectively. The ideal value is 0.00 (the closer to 0.00, the better).

```
TABLE 3.1 Keyakinan                                              Dec 19 14:42 2023
INPUT: 160 Person  60 Item  REPORTED: 160 Person  60 Item  5 CATS  WINSTEPS 3.73
--------------------------------------------------------------------------------

     SUMMARY OF 160 MEASURED Person
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE   ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     195.4      60.0         .36     .15      1.01     .0   1.03     .1 |
| S.D.      12.1        .0         .28     .00       .28    1.5    .32    1.4 |
| MAX.     241.0      60.0        1.50     .17      1.90    3.8   1.77    2.8 |
| MIN.     160.0      60.0        -.47     .15       .45   -3.5    .46   -2.9 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .16 TRUE SD     .23  SEPARATION  1.44  Person RELIABILITY  .67 |
|MODEL RMSE    .15 TRUE SD     .24  SEPARATION  1.56  Person RELIABILITY  .71 |
| S.E. OF Person MEAN = .02                                                   |
-------------------------------------------------------------------------------
Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .70

     SUMMARY OF 60 MEASURED Item
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE   ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     521.0     160.0         .00     .10      1.03     .2   1.03     .2 |
| S.D.     155.0        .0        1.21     .03       .29    1.8    .28    1.8 |
| MAX.     735.0     160.0        2.54     .16      2.40    6.7   2.34    6.7 |
| MIN.     244.0     160.0       -2.22     .07       .51   -3.5    .48   -3.7 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .11 TRUE SD    1.20  SEPARATION 10.52  Item   RELIABILITY  .99 |
|MODEL RMSE    .11 TRUE SD    1.20  SEPARATION 11.31  Item   RELIABILITY  .99 |
| S.E. OF Item MEAN = .16                                                     |
-------------------------------------------------------------------------------
UMEAN=.0000 USCALE=1.0000
Item RAW SCORE-TO-MEASURE CORRELATION = -.99
9600 DATA POINTS. LOG-LIKELIHOOD CHI-SQUARE: 16345.56 with 9378 d.f. p=.0000
Global Root-Mean-Square Residual (excluding extreme scores): .8484
```

Figure 1. Quality output of respondents and instruments

Instrument validity

Instrument validity tests whether the instrument developed can be used to measure prospective teachers' abilities in solving mathematical problems. The tables used in the Winstep software are Item unidimensionality and item fit order. Undimensionality is an important measure to evaluate whether the instrument for prospective mathematics teacher students' mathematical beliefs developed by researchers can measure what it is supposed to measure (Andrich & Marais, 2019; Sharif et al., 2019; Sumintono & Widhiarso, 2015). Rasch model analysis uses principal component analysis of residuals, namely measuring the extent of diversity of instruments that measure what should be measured. Clearly presented in Figure 2 shows that the total value of raw variance in observations is 57.6%. Referring to the opinion of Sumintono & Widhiarso (2014) explain that the minimum unidimensionality requirement is 20%, and the unidimensionality value in instrument development can be met. In addition, it is clear that the variance that cannot be explained by the beliefs instrument is 3.5% with an eigenvalue of 5.0.

TABLE 23.0 Keyakinan Dec 19 14:42 2023
INPUT: 160 Person 60 Item REPORTED: 160 Person 60 Item 5 CATS WINSTEPS 3.73

Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)

		-- Empirical --			Modeled
Total raw variance in observations	=	141.5	100.0%		100.0%
Raw variance explained by measures	=	81.5	57.6%		58.1%
Raw variance explained by persons	=	8.2	5.8%		5.9%
Raw Variance explained by items	=	73.3	51.8%		52.2%
Raw unexplained variance (total)	=	60.0	42.4%	100.0%	41.9%
Unexplned variance in 1st contrast	=	5.0	3.5%	8.3%	
Unexplned variance in 2nd contrast	=	3.0	2.1%	5.1%	
Unexplned variance in 3rd contrast	=	2.8	2.0%	4.7%	
Unexplned variance in 4th contrast	=	2.4	1.7%	3.9%	
Unexplned variance in 5th contrast	=	2.3	1.6%	3.8%	

Figure 2. Unidimensionality value

TABLE 10.1 Keyakinan Dec 19 14:42 2023
INPUT: 160 Person 60 Item REPORTED: 160 Person 60 Item 5 CATS WINSTEPS 3.73

Person: REAL SEP.: 1.44 REL.: .67 ... Item: REAL SEP.: 10.52 REL.: .99

Item STATISTICS: MISFIT ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
10	712	160	-1.71	.14	2.40	6.7	2.34	6.7	A .30	.15	46.9	55.2	10
19	265	160	2.12	.13	1.73	3.6	1.59	3.1	B .33	.17	45.6	59.3	19
48	278	160	1.91	.13	1.62	3.0	1.60	2.9	C .20	.19	50.0	63.1	48
5	735	160	-2.22	.16	1.61	4.6	1.57	4.5	D .24	.14	65.0	60.0	5
29	426	160	.63	.07	1.31	3.6	1.29	3.1	E .38	.29	20.0	23.5	29
11	724	160	-1.96	.15	1.26	1.9	1.25	1.9	F .17	.14	60.6	55.5	11
24	723	160	-1.94	.15	1.25	1.8	1.23	1.7	G .19	.15	53.1	55.4	24
18	573	160	-.16	.08	1.17	1.8	1.24	2.1	H .26	.26	36.9	42.3	18
32	685	160	-1.22	.13	1.22	1.2	1.11	.7	I .39	.17	56.9	62.1	32
26	642	160	-.68	.10	1.15	1.0	1.21	1.3	J .22	.21	64.4	66.8	26
3	716	160	-1.79	.15	1.17	1.1	1.18	1.3	K .23	.15	59.4	54.8	3
49	702	160	-1.51	.14	1.16	1.0	1.13	.8	L .39	.16	58.8	57.6	49
36	679	160	-1.13	.12	1.14	.8	1.16	.9	M .33	.17	59.4	63.5	36
8	602	160	-.35	.08	1.11	1.0	1.15	1.2	N .15	.24	53.1	57.1	8
14	498	160	.26	.07	1.12	1.7	1.15	2.0	O-.04	.29	6.3	9.3	14
38	287	160	1.77	.12	1.14	.8	1.10	.6	P .28	.20	60.0	64.6	38
56	402	160	.77	.08	1.12	1.3	1.12	1.3	Q .32	.29	30.6	35.7	56
28	623	160	-.51	.09	1.08	.6	1.11	.8	R .23	.22	64.4	64.8	28
6	492	160	.29	.07	1.05	.8	1.11	1.6	S-.14	.29	6.3	9.6	6
12	449	160	.51	.07	1.09	1.3	1.08	1.1	T .26	.30	15.0	15.6	12
53	634	160	-.60	.10	1.08	.6	1.09	.6	U .13	.22	66.9	66.0	53
47	440	160	.56	.07	1.08	1.1	1.07	.9	V .34	.29	18.8	16.5	47
31	423	160	.65	.07	1.06	.8	1.08	1.0	W .22	.29	24.4	23.6	31
57	518	160	.15	.07	1.05	.7	1.07	.9	X .14	.28	9.4	13.4	57
39	338	160	1.21	.09	1.07	.5	1.05	.4	Y .20	.25	61.3	64.2	39
2	534	160	.07	.07	1.00	.0	1.07	.8	Z .04	.28	16.9	19.8	2
BETTER FITTING OMITTED													
22	501	160	.24	.07	.97	-.4	.98	-.3	z .22	.29	8.8	9.3	22
58	678	160	-1.11	.12	.96	-.2	.96	-.1	y .29	.18	63.8	63.7	58
4	603	160	-.35	.08	.96	-.3	.94	-.5	x .24	.24	61.3	57.2	4
33	253	160	2.35	.14	.95	-.3	.89	-.7	w .23	.16	54.4	55.8	33
1	439	160	.56	.07	.95	-.7	.95	-.6	v .15	.29	18.1	17.7	1
37	556	160	-.05	.08	.92	-1.0	.94	-.6	u .32	.27	33.8	30.4	37
43	398	160	.79	.08	.94	-.7	.93	-.7	t .44	.29	39.4	37.9	43
25	683	160	-1.19	.12	.91	-.5	.93	-.3	s .21	.17	63.8	62.6	25
23	717	160	-1.81	.15	.92	-.5	.91	-.6	r .28	.15	60.6	54.8	23
21	384	160	.88	.08	.92	-.8	.90	-.9	q .18	.28	50.6	46.8	21
34	423	160	.65	.07	.91	-1.1	.91	-1.0	p .38	.29	24.4	23.6	34
59	643	160	-.69	.10	.85	-1.0	.89	-.7	o .28	.21	71.3	66.8	59
9	702	160	-1.51	.14	.88	-.7	.88	-.7	n .26	.16	61.9	57.6	9
60	688	160	-1.27	.13	.86	-.8	.88	-.7	m .31	.17	63.1	61.3	60
30	660	160	-.87	.11	.84	-.9	.87	-.7	l .16	.19	72.5	65.9	30
42	300	160	1.60	.11	.85	-.8	.86	-.8	k .04	.22	73.1	66.5	42
52	595	160	-.30	.08	.85	-1.3	.84	-1.3	j .20	.25	59.4	52.9	52
54	333	160	1.26	.09	.85	-1.0	.81	-1.3	i .39	.25	67.5	64.4	54
44	672	160	-1.03	.12	.84	-.9	.85	-.8	h .31	.18	67.5	64.8	44
17	244	160	2.54	.15	.82	-1.3	.84	-1.2	g .19	.16	57.5	54.8	17
41	343	160	1.17	.09	.75	-2.0	.78	-1.6	f .25	.26	71.3	63.3	41
50	661	160	-.89	.11	.63	-2.4	.65	-2.2	e .40	.19	74.4	66.2	50
16	633	160	-.59	.10	.60	-3.2	.58	-3.2	d .33	.22	77.5	65.9	16
55	298	160	1.63	.11	.57	-2.9	.54	-3.1	c .07	.21	79.4	66.3	55
51	659	160	-.86	.11	.53	-3.3	.54	-3.1	b .22	.19	78.1	66.0	51
35	307	160	1.52	.11	.51	-3.5	.48	-3.7	a .22	.22	80.6	67.1	35
MEAN	521.0	160.0	.00	.10	1.03	.2	1.03	.2			50.4	49.4	
S.D.	155.0	.0	1.21	.03	.29	1.8	.28	1.8			21.4	19.3	

Figure 3. Item fit order output in winstep

After the item unidimensionality stage, it continues with the item fit order. To check items that are Fit and Misfit, the INFIT MNSQ value of each item is used. The average value and standard deviation are added up and then compared; a logit value more excellent than this value indicates a misfit item. Other criteria, according to Sumintono & Widhiarso (2015) which are used to check the suitability of inappropriate question items (Outliers or Misfits) are: 1) Acceptable Outfit Mean Square (MNSQ) value: 0.5 < MNSQ < 1.5; 2) Outfit Z-Standard (ZSTD) value received: -2.0 < ZSTD < +2.0; and 3) Point Measure Correlation (Pt Mean Corr) value received: 0.4 < Pt Measure Corr < 0.85. A valid item meets at least one of these three criteria. For example, in the first row are the output results for item number 10 on the prospective teacher beliefs instrument in solving mathematical problems, respectively the scores are 2.34 and 6.7 and 0.30. The third row is item 48, whose scores are 1.60, 2.9, and 0.20, respectively. The item fit order output is presented in Figure 3 in detail.

Validity testing by paying attention to the rating results (partial-credit) found that each rating (1, 2, 4, 5) had a separate peak. This means that the probability of each rating is visible to the research respondents. Figure 4 shows that the instrument for prospective teachers' beliefs in solving mathematical problems can be differentiated in their ratings by research respondents.

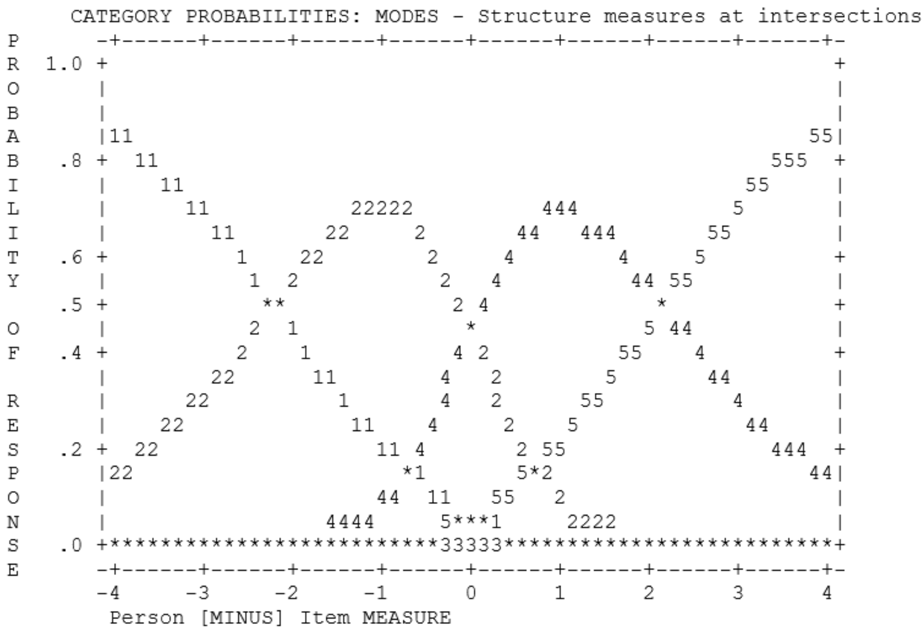

Figure 4. Rating (partial–credit) scale results

The test results use item measures and variable maps to determine which items are most difficult for respondents to agree with and the easiest to blend with respondents (Adi et al., 2022; Boone, 2016; Saidi & Siew, 2019). Figure 5 shows that the measure logit items have been sorted from highest to lowest logit value. The 17th item with 2.54 logits shows that this item is the most difficult to agree on, while the 5th item with -2.22 logits is the item that is most easily agreed upon by respondents in the instrument of problem solving beliefs for prospective mathematics teacher students. Furthermore, taking into account the standard deviation value of 1.21, this means that the range of item difficulty levels is quite diverse so there is no need to correct it.

TABLE 13.1 Keyakinan Dec 19 14:42 2023
INPUT: 160 Person 60 Item REPORTED: 160 Person 60 Item 5 CATS WINSTEPS 3.73

Person: REAL SEP.: 1.44 REL.: .67 ... Item: REAL SEP.: 10.52 REL.: .99

Item STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
17	244	160	2.54	.15	.82	-1.3	.84	-1.2	.19	.16	57.5	54.8	17
33	253	160	2.35	.14	.95	-.3	.89	-.7	.23	.16	54.4	55.8	33
19	265	160	2.12	.13	1.73	3.6	1.59	3.1	.33	.17	45.6	59.3	19
48	278	160	1.91	.13	1.62	3.0	1.60	2.9	.20	.19	50.0	63.1	48
38	287	160	1.77	.12	1.14	.8	1.10	.6	.28	.20	60.0	64.6	38
55	298	160	1.63	.11	.57	-2.9	.54	-3.1	.07	.21	79.4	66.3	55
42	300	160	1.60	.11	.85	-.8	.86	-.8	.04	.22	73.1	66.5	42
35	307	160	1.52	.11	.51	-3.5	.48	-3.7	.22	.22	80.6	67.1	35
54	333	160	1.26	.09	.85	-1.0	.81	-1.3	.39	.25	67.5	64.4	54
39	338	160	1.21	.09	1.07	.5	1.05	.4	.20	.25	61.3	64.2	39
27	342	160	1.18	.09	1.04	.3	1.04	.3	.12	.26	63.8	63.3	27
41	343	160	1.17	.09	.75	-2.0	.78	-1.6	.25	.26	71.3	63.3	41
46	351	160	1.11	.09	.99	-.1	.99	.0	.31	.26	58.8	59.8	46
45	368	160	.98	.08	.99	-.1	.96	-.3	.32	.27	56.9	55.6	45
15	374	160	.94	.08	1.04	.4	1.04	.4	.16	.28	53.1	52.1	15
21	384	160	.88	.08	.92	-.8	.90	-.9	.18	.28	50.6	46.8	21
43	398	160	.79	.08	.94	-.7	.93	-.7	.44	.29	39.4	37.9	43
56	402	160	.77	.08	1.12	1.3	1.12	1.3	.32	.29	30.6	35.7	56
31	423	160	.65	.07	1.06	.8	1.08	1.0	.22	.29	24.4	23.6	31
34	423	160	.65	.07	.91	-1.1	.91	-1.0	.38	.29	24.4	23.6	34
29	426	160	.63	.07	1.31	3.6	1.29	3.1	.38	.29	20.0	23.5	29
1	439	160	.56	.07	.95	-.7	.95	-.6	.15	.29	18.1	17.7	1
47	440	160	.56	.07	1.08	1.1	1.07	.9	.34	.29	18.8	16.5	47
12	449	160	.51	.07	1.09	1.3	1.08	1.1	.26	.30	15.0	15.6	12
7	462	160	.44	.07	1.01	.2	1.00	.1	.37	.29	11.9	11.5	7
6	492	160	.29	.07	1.05	.8	1.11	1.6	-.14	.29	6.3	9.6	6
14	498	160	.26	.07	1.12	1.7	1.15	2.0	-.04	.29	6.3	9.3	14
22	501	160	.24	.07	.97	-.4	.98	-.3	.22	.29	8.8	9.3	22
20	513	160	.18	.07	.97	-.5	.98	-.3	.26	.29	11.9	11.8	20
57	518	160	.15	.07	1.05	.7	1.07	.9	.14	.28	9.4	13.4	57
2	534	160	.07	.07	1.00	.0	1.07	.8	.04	.28	16.9	19.8	2
37	556	160	-.05	.08	.92	-1.0	.94	-.6	.32	.27	33.8	30.4	37
18	573	160	-.16	.08	1.17	1.8	1.24	2.1	.26	.26	36.9	42.3	18
52	595	160	-.30	.08	.85	-1.3	.84	-1.3	.20	.25	59.4	52.9	52
8	602	160	-.35	.08	1.11	1.0	1.15	1.2	.15	.24	53.1	57.1	8
4	603	160	-.35	.08	.96	-.3	.94	-.5	.24	.24	61.3	57.2	4
28	623	160	-.51	.09	1.08	.6	1.11	.8	.23	.22	64.4	64.8	28
16	633	160	-.59	.10	.60	-3.2	.58	-3.2	.33	.22	77.5	65.9	16
53	634	160	-.60	.10	1.08	.6	1.09	.6	.13	.22	66.9	66.0	53
26	642	160	-.68	.10	1.15	1.0	1.21	1.3	.22	.21	64.4	66.8	26
59	643	160	-.69	.10	.85	-1.0	.89	-.7	.28	.21	71.3	66.8	59
51	659	160	-.86	.11	.53	-3.3	.54	-3.1	.22	.19	78.1	66.0	51
30	660	160	-.87	.11	.84	-.9	.87	-.7	.16	.19	72.5	65.9	30
50	661	160	-.89	.11	.63	-2.4	.65	-2.2	.40	.19	74.4	66.2	50
40	666	160	-.95	.11	.92	-.4	.98	.0	.22	.19	67.5	65.7	40
44	672	160	-1.03	.12	.84	-.9	.85	-.8	.31	.18	67.5	64.8	44
58	678	160	-1.11	.12	.96	-.2	.96	-.1	.29	.18	63.8	63.7	58
36	679	160	-1.13	.12	1.14	.8	1.16	.9	.33	.17	59.4	63.5	36
25	683	160	-1.19	.12	.91	-.5	.93	-.3	.21	.17	63.8	62.6	25
32	685	160	-1.22	.13	1.22	1.2	1.11	.7	.39	.17	56.9	62.1	32
60	688	160	-1.27	.13	.86	-.8	.88	-.7	.31	.17	63.1	61.3	60
9	702	160	-1.51	.14	.88	-.7	.88	-.7	.26	.16	61.9	57.6	9
49	702	160	-1.51	.14	1.16	1.0	1.13	.8	.39	.16	58.8	57.6	49
13	711	160	-1.69	.14	1.06	.4	1.06	.4	.17	.15	58.1	55.4	13
10	712	160	-1.71	.14	2.40	6.7	2.34	6.7	.30	.15	46.9	55.2	10
3	716	160	-1.79	.15	1.17	1.1	1.18	1.3	.23	.15	59.4	54.8	3
23	717	160	-1.81	.15	.92	-.5	.91	-.6	.28	.15	60.6	54.8	23
24	723	160	-1.94	.15	1.25	1.8	1.23	1.7	.19	.15	53.1	55.4	24
11	724	160	-1.96	.15	1.26	1.9	1.25	1.9	.17	.14	60.6	55.5	11
5	735	160	-2.22	.16	1.61	4.6	1.57	4.5	.24	.14	65.0	60.0	5
MEAN	521.0	160.0	.00	.10	1.03	.2	1.03	.2			50.4	49.4	
S.D.	155.0	.0	1.21	.03	.29	1.8	.28	1.8			21.4	19.3	

Figure 5. Items measure test results

Discussion

The instrument of prospective teacher beliefs in solving the mathematical problems studied is highly reliable. Table 2 shows that the Cronbach alpha interpretation is good. This indicates a match between the research instrument items and the research respondents. Then, the consistency of the respondents' answers can be considered sufficient, with the quality of the research instrument items being excellent. This shows that the instrument of prospective teachers' beliefs in solving mathematical problems can be reliable and provide relatively stable results when used by other researchers. An instrument that has high reliability is one of the characteristics of a good instrument (Huei et al., 2020; Indihadi et al., 2022; Sharif et al., 2019; Sumintono & Widhiarso, 2015).

Table 2. Results of instrument reliability test analysis

Cronbach Alpha	Interpreta-tion	Item Reliability	Interpreta-tion	Person Reliability	Interpreta-tion	Conclusion
0.70	Good	0.99	Excellent	0.67	Fairly	Reliable

Instrument validity is used to test how far the test items can measure prospective teacher beliefs and abilities in solving mathematical problems (Huei et al., 2020; Sumintono & Widhiarso, 2014). The validity test based on item unidimensionality shows that the total value of raw variance in observations is 57.6%. Interpretation of item unidimensionality based on the raw variance explained by measures value is indicated by a score of > 20%, which is said to be fulfilled, > 40% is good, and > 60% is for special criteria. Furthermore, to find out whether or not there are instrument items that do not match, you can look at the eigenvalue and observed values in the unexplained variance 1st contrast. The eigenvalue must be less than 3 to indicate no problematic instrument items, and the observed value must be less than 15% to show appropriate instrument items (Sumintono & Widhiarso, 2015). The analysis results concluded that there was no tendency for item discrepancies so that the instrument could be used. An eigenvalue of more than 3 indicates a problematic instrument item, so an item fit order analysis is carried out to determine whether the instrument item can be retained or discarded. A complete summary of the results of the validity analysis using Winstep 3.73 software is presented in Table 3.

Table 3. Results of instrument validity test analysis

Raw variance explained by measures	Interpretation	Unexplained variance 1st contrast		Interpretation
		Eigenvalue	observed	
57.6%	Good	5.0	3.5%	There are problematic items

Item fit is used to explain whether the instrument items usually function to carry out measurements. To see whether an item fits or not, the outfit means-square, outfit z-standard, and point measure correlation values are used (Huei et al., 2020; Saidi & Siew, 2019; Sharif et al., 2019; Sumintono & Widhiarso, 2015). The criteria used to check the suitability of items are: 1) Acceptable Outfit Mean Square (MNSQ) value: 0.5 < MNSQ < 1.5; 2) Outfit Z-Standard

(ZSTD) value received: -2.0 < ZSTD < +2.0; and 3) Point Measure Correlation (PT Mean Corr) value received: 0.4 < Pt Measure Corr < 0.85. An instrument item is valid if it meets at least one of these criteria. If the three criteria are met on an instrument item, it is said that the item is "suitable," and it can be confirmed that the quality of the instrument item is good and can be used. However, if only two criteria or one criterion are met, the instrument item can still be maintained and does not need to be changed. Table 4 summarizes the results of the analysis of invalid instrument items.

Table 4. Invalid items

Item	Statement	Outfit MNSQ	Outfit ZTSD	PT Measure Corr	Information
5	Mathematical problem-solving abilities increase if you study	1.57	4.5	0.24	Invalid
10	Everyone cannot solve problems	2.34	6.7	0.30	Invalid
19	A good math teacher shows students the right way to answer math questions	1.59	3.1	0.33	Invalid
35	Mathematics is a collection of processes and rules which describe exactly how to solve a problem	0.48	-3.7	0.22	Invalid
48	A calm environment is needed for mathematics learning so that students can focus on listening to explanations of the material	1.60	2.9	0.20	Invalid

In accordance with the analysis's results, five instrument items that did not meet the validity criteria were obtained, so it could be said that these items were invalid (Misfit) and could not be maintained. Overall, the development of the instrument for measuring prospective teacher beliefs in solving mathematical problems in this study was declared reliable and valid, with 55 of the 60 statement items said to be useful.

The results of the research can explain the relationship between the probability of answering questions and the respondent's ability. This has not been found in the development of previous instruments to measure beliefs about mathematical problem-solving. Rasch modeling can help to address item measurements more consistently and correctly (Adi et al., 2022; Andrich & Marais, 2019; Boone, 2016). Another advantage of Rasch modeling is that three reliabilities are obtained: person reliability, item reliability, and Cronbach's alpha (Saidi & Siew, 2019; Sumintono & Widhiarso, 2015). Furthermore, Rasch modeling can be used to evaluate the construct validity of the instruments developed. The Rasch model can show instrument items that are difficult for respondents to agree on while also matching the respondent's abilities (Adi et al., 2022; Boone, 2016; Saidi & Siew, 2019). Analysis of instrument items related to the respondent's abilities is beneficial in preparing instruments to cover the aspects to be measured (Kaspersen et al., 2017; Sharif et al., 2019; Sumintono & Widhiarso, 2014).

Conclusion

Using Rasch modeling in instrument validation has produced more holistic information about the instruments being developed. Based on the test results, it was concluded that the instrument for prospective teacher beliefs in solving mathematical problems was declared reliable and valid. A total of five instrument items did not meet the validity criteria. Thus, fifty-five instrument items were obtained to measure prospective teachers' beliefs in solving mathematical problems. Researchers are aware of the limitations of this research, namely that research respondents are only limited to students who are in the same class, namely sixth semester students. This causes the person separation result to be less than 2, which means that the respondent not have level diversity.

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Conflicts of Interest

The author declares no conflict of interest regarding the publication of this manuscript.

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Appendix

Questionnaire on belifes about about mathematical problem-solving for prospective teacher.

Item	Questionnaire Statement
1	Math problems that take a long time to solve are not a problem for me
2	There are problems that cannot be resolved by following the specified steps
3	Apart from getting the right solution, the most important thing is why the solution is right
4	Mathematicians solve given mathematical problems with the same solution
5	Mathematical problem-solving abilities increase if you study *)
6	You feel like you can solve math problems for a long time
7	Problems can be solved without remembering formulas
8	It is not important to understand how the mathematical procedure works, as long as it provides the correct solution
9	If you are unable to solve a problem one way, there are other solutions to get the right answer
10	Everyone cannot solve problems *)
11	You can solve difficult problems if you try
12	Memorizing steps is useless for solving math problems
13	An individual truly solves a problem if he has a good understanding of the solution obtained
14	To solve problems correctly use different methods from textbooks or teachers
15	Worries about solving the problem prevent solving the problem
16	Mathematical problems that take time to solve, cannot be solved
17	Problems can be solved if you know the right steps to follow
18	It doesn't matter how to understand the math problem, as long as you get the correct solution
19	A good math teacher shows students the right way to answer math questions *)
20	Problem-solving is a difficult activity
21	If you stop solving a problem for a long time, you forget how to solve it
22	Mathematical problems can only be solved using procedures
23	In addition to getting the correct solution in mathematics, it is also important to understand why the solution is correct
24	Developing a strategy for solving problems is better than just finding the right answer
25	If there is motivation to solve a problem, a solution will be found
26	If we cannot solve this for some time, there is no point in making efforts to find a solution
27	Mathematics rarely has step-by-step procedures for solving problems
28	Math solutions are better than focusing on the right answer
29	Math problems have one and only one correct answer
30	When attention is paid to a problem, a solution will be found
31	A strategy that is effective in solving one problem is also effective for other problems
32	Memorizing is the only way to solve problems
33	Students must be taught the correct procedures for solving mathematical problems
34	To be able to solve math problems, I have to remember many methods
35	Mathematics is a collection of processes and rules which describe exactly how to solve a problem *)

Item	Questionnaire Statement
36	Mathematics learning objectives will be very good when students find their own methods in solving problems
37	A good test is a routine question test that relies on a textbook
38	Teachers should convey detailed procedures in the process of finding solutions to mathematical problems
39	Students learn best when through illustrations and explanations from the teacher
40	Math tests and problems can be solved in many ways correctly
41	Learning goal orientation is the result of student performance which is demonstrated by students being able to solve problems
42	The most effective solution in solving the problem should be implemented through practice first
43	Students learn best when the solution process is demonstrated by the teacher
44	The teacher gives students the opportunity to solve their difficulties in solving problems with their own approach
45	If you want to solve math problems, you must be able to understand the proper procedures, otherwise you will not be able to solve the problem
46	Students can become good probe solvers when they follow the teacher's instructions completely
47	Students can find solutions to many math problems without help from teachers
48	A calm environment is needed for mathematics learning so that students can focus on listening to explanations of the material *)
49	Students are given the opportunity to discuss their own ideas for solving mathematical problems
50	In mathematics, you can discover and try many ways with what is within yourself
51	Students can develop procedural calculations independently with the help of appropriate materials
52	Teachers encourage students to look at their working solutions on math tests, even if the solutions are inefficient
53	Students have the opportunity to explore their solutions in detail, even if these are incorrect
54	Students need detailed instructions for solving math problems
55	Mathematics is the memory and application of definitions and formulas of mathematical facts and procedures
56	To be successful in mathematics students must be good listeners in learning
57	A good problem is a test in the form of non-routine questions to develop thinking and problem-solving abilities
58	The classroom environment is open and informal to ensure students' freedom to ask questions and express their ideas
59	Students should think about their solutions to math problems before the teacher demonstrates how to solve them
60	Teachers encourage students to think about solutions to mathematical problems in their way

* Invalid items questionnaire