Journal of Education and Learning (EduLearn)
Vol. 18, No. 2, May 2024, pp. 391~402
ISSN: 2089-9823 DOI: 10.11591/edulearn.v18i2.21343

Readiness of Indonesian pre-service science teachers for society 5.0

Irwandani Irwandani, Agus Suyatna, Een Yayah Haenilah, Dina Maulina
Department of Education, Faculty of Teacher Training and Education, Universitas Lampung, Lampung, Indonesia

Article Info

Article history:

Received Oct 10, 2023
Revised Oct 26, 2023
Accepted Nov 8, 2023

Keywords:

Future skills
Pre-service teachers
Rasch analysis
Society 5.0 era

ABSTRACT

This research aimed to assess the readiness of Indonesian pre-service science teachers by examining their perceptions of impending challenges, desired competencies, and anticipated instructional methodologies in preparing for the challenges of Society 5.0. Using a quantitative survey research methodology, 884 pre-service science teachers from 16 universities were surveyed. The research instrument's validity and reliability were assessed utilizing the Rasch model. Inferential statistics were employed to assess the readiness of pre-service science teachers for future challenges, taking into account their backgrounds. The test outcomes showed the Cronbach's Alpha coefficient reached 0.92, is deemed "excellent", affirming the instrument's high reliability. The findings of the study revealed that the majority of teachers share a consistent perception of future challenges and recognize the importance of mastering 21st-century skills, particularly critical thinking, creative thinking, communication, and collaboration. However, respondents believe that the current learning process does not adequately train these skills. They expressed a desire for an alternative learning method that can enhance their skills while accommodating their diverse backgrounds, including place of residence, economic background, and technological proficiency. Further research is needed to identify alternative teaching methods that can effectively foster these abilities in diverse backgrounds.

Corresponding Author:

Agus Suyatna
Department of Education, Faculty of Education and Teacher Training, Universitas Lampung
Bandar Lampung, 35141, Indonesia
Email: agus.suyatna@fkip.unila.ac.id

1. INTRODUCTION

Contemporary education is faced with a variety of complex, fast-paced, and multidimensional opportunities and challenges that are constantly evolving [1], [2]. These include technological advances, demographic changes, environmental problems, and other emerging life challenges, such as those caused by the COVID-19 pandemic. As the frontline in education, teachers play a critical role in preparing the next generation to face these challenges [3]–[6]. Relevant knowledge and skills are essential assets that future teachers must possess, including pre-service teachers who are currently undergoing education in higher educational institutions [7]–[9].

In the Society 5.0 era, where technological advancements and digitalization are prevalent, the skill and competency requirements for teachers are increasingly complex and multidimensional [10]–[12]. However, higher education institutions in Indonesia, where students majoring in science aspire to become future science teachers, continue to uphold conventional pedagogical approaches that are deeply ingrained in their practices [13]–[15]. Such as, many higher education institutions in Indonesia heavily rely on lecture-based teaching methods, where instructors predominantly deliver content to passive learners [16]. However, in this 5.0 era, the needs and challenges of society have also evolved. Therefore, learning should adapt to those needs. Figure 1 illustrates the transformation of society from one era to another, starting from the hunting society to Society 5.0.

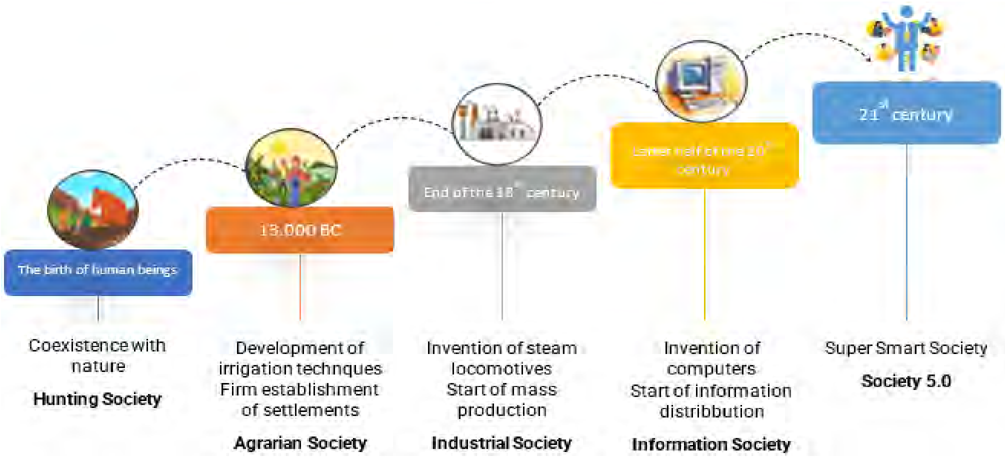

Figure 1. An infographic illustrating the development of society, from the hunting society era to Society 5.0

Figure 1 depicts the phases of societal transformation. During the hunting society phase, people coexisted with nature, and the law of the jungle prevailed. In the Agrarian Society era, communities started learning to extract more benefits from nature, leading them to acquire farming skills. The Industrial Society era marked the advent of the industrial revolution, with machines and factories being mass-produced and utilized for broader purposes. This period also witnessed the massive development of education. In the Information Society era, computers and the internet began to thrive, facilitating faster and easier access to information. The use of computers and the internet for learning started during this time. In the Society 5.0 era, the concept of Society 5.0 emerged, particularly in Japan, emphasizing the integration of advanced technologies like artificial intelligence, the internet of things (IoT), and robotics into daily life. This created a highly interconnected society where technology acts to enhance the quality of life and address social issues, such as an aging population and climate change. In this era, everyday learning should no longer be separate from technology, and each learning experience should cultivate critical and creative thinking, as well as collaborative and communication skills [10], [11].

The prevalence of teacher-centered approaches in Indonesian higher education is evident in the limited incorporation of student-centered and active learning methods. A study conducted by Syaharuddin et al. found that student-centered teaching practices were not widely adopted, with traditional approaches still dominant [17]. Conventional pedagogical methods persist due to various factors, including resistance to change and institutional inertia [18], [19]. This paradigm demonstrates a tendency to invest in established and historically rooted pedagogical patterns [2], [20], [21]. Although such approaches may have been effective in their time, they are less suitable and potentially inadequate in equipping pre-service teachers with the necessary skills and understanding to face the challenges of the new era in the Society 5.0 context [21]–[23] . Rapid advancements in technology and changes in social and economic structures demand an innovative and adaptive educational paradigm [1], [24]–[26]. Therefore, it is crucial for higher education institutions to design and implement a curriculum and teaching methods more aligned with current demands, preparing pre-service teachers to face challenges in the Society 5.0 era [10], [11].

Over the past three years, research on the readiness of pre-service science teachers for future challenges in developing countries like Indonesia is limited. A Google Scholar search using the keywords "the readiness of pre-service science teachers to face future challenges in Indonesia" yielded no precise discussions on this topic. While some studies have discussed the competencies required by future teachers, such as critical thinking abilities, digital literacy, communication skills, and entrepreneurship [11], [27], [28], few have employed the Rasch analysis approach, an effective method to measure and analyze individuals' readiness to confront various challenges. This approach has not been extensively used to assess the readiness of pre-service teachers in Indonesia, particularly in the post-pandemic context. Therefore, this study aims to fill this gap by employing the Rasch analysis approach to observe and analyze the readiness level of pre-service teachers in Indonesia for the post-pandemic future. Rasch analysis is a data measurement and analysis method based on a logistic model, which has been shown to be effective in gauging individuals' abilities and readiness levels in educational contexts [29]–[32]. This approach will enable this study to provide new and in-depth insights into the readiness of pre-service teachers in Indonesia for future challenges, which could inform future teacher education policies and practices.

In light of this background, this research aims to provide a more in-depth picture of the readiness of pre-service teachers in Indonesia in facing future challenges by utilizing the Rasch analysis approach. We hypothesize that by gaining a deeper understanding of pre-service teachers' readiness, we can assist in formulating more effective learning strategies in higher education institutions to enhance the quality of pre-service teachers and help them prepare for future challenges.

Although some research related to pre-service science teachers' readiness for Society 5.0 has been found, no study has yet discussed it in detail from various perspectives. Some studies have only focused on one variable, such as educational institution factors [33], while others have presented the results of an analysis of prospective teachers' strengths in several aspects [34]. Still others have provided a comparative picture of the readiness of Indonesian and Thai teachers in facing future challenges [35]. Another study also showed how some majority of pre-service teachers aware about the importance of mastering 21st century skills [36], numeroues studies also corroborate this finding [37]–[40]. However, no study has yet provided a detailed approach to understanding the readiness of pre-service science teachers. Therefore, this research represents one of the first attempts to use the Rasch analysis approach to understand the readiness of pre-service teachers in Indonesia. This study has the potential to significantly contribute to the existing literature and provide valuable insights for education policymakers and practitioners. Through this research, we assessed the readiness of Indonesian pre-service science teachers by examining their perceptions of impending challenges, desired competencies, and anticipated instructional methodologies in preparing for the challenges of Society 5.0. And for that, we hope to discover ways to help prepare pre-service teachers who are more ready for the future and better prepared to face challenges in the Society 5.0 era.

2. METHOD

2.1. Instruments

A survey method was used in this study. The questionnaire consisted of demographic questions (gender, age, university background, previous school background, residence, economic status, and Information and communication technology (ICT) knowledge), pre-service teacher students' perceptions of their future profession (7 items), classroom learning implementation (9 items), and 21st-century skills they aim to achieve (9 items). Every item underwent assessment through a 5-point Likert scale, encompassing choices spanning from strongly disagree to strongly agree.

2.2. Participants

This study employed a convenience sampling technique, where the survey was conducted online using a Google form. In total, 884 science teacher trainees (Physics, Biology, and Chemistry Education) from various public and private universities in Indonesia participated voluntarily and anonymously. The respondents were from 16 universities spread across five major islands and some small islands in Indonesia: Java, Sumatra, Kalimantan, Sulawesi, Papua, Bali and East Nusa Tenggara. The geographical distribution of respondents is displayed in Figure 2.

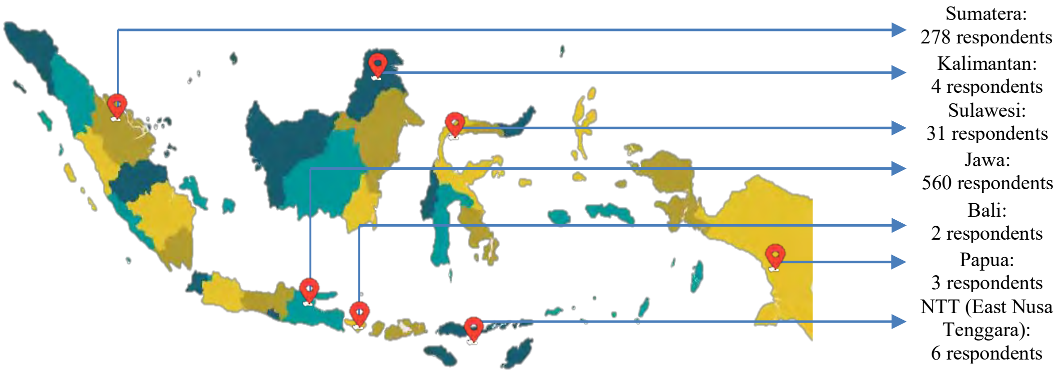

Figure 2. The geographical distribution of respondents

Then, the demographic profile of the respondents is shown in Table 1.

Table 1. Demographic profile of respondents (N = 884)

Demographics		Frequency	Percentage (%)
Gender	Male	198	22.4
	Female	686	77.6
Age	17 - 20 years	456	51.6
	20 - 24 years	406	45.9
	25 years and above	22	2.5
University type	Public	704	79.6
	Private	180	20.4
School origin major	Vocational	84	9.5
	Non-Vocational	800	90.5
Living location	City	228	25.8
	District	656	74.2
Economic status	Low	70	7.9
	Moderate	778	88.0
	High	36	4.1
ICT knowledge	Low	124	14.0
	Moderate	752	85.1
	High	8	0.9

2.3. Measurement model and data analysis

This study used a Rasch measurement model. The Rasch model can be used to analyze data from both the quality of the instrument and the respondents [31], [41]. The collected data was entered into Excel and then uploaded to Winsteps 5.2.3.0 for processing. Rasch measurement models were used for validation and data cleaning when deviations were detected [31]. Within the framework of Rasch analysis, the outcomes provide a meticulous gauge of item difficulty, discern discrepancies in item fit, and unveil indications of item bias, often denoted as differential item functioning (DIF) [42]. Utilizing the WINSTEPS 5.2.3.0 software, raw ordinal data (Likert scale data) from the respondents was mathematically transformed into logits through a logarithmic function. In contrast to classical test theory, which leans on scores unable to deliver an exact and meticulous measurement of the underlying attribute, this methodology takes a divergent route [42], [43].

The Winsteps output was used to test preservice science teachers' readiness for future challenges based on descriptive statistical values and the logit value of item and person calibration, or person logit value. The mean scores were represented on a logit scale. Consequently, a positive person logit signifies the above-average perceived readiness of pre-service science teachers for future challenges, while a negative value suggests readiness below the expected average. Elevated logit scores correspond to heightened future challenge readiness. Subsequently, inferential statistics were employed to examine diverse responses linked to demographic variables—gender, age, university type, major, and residence location, with additional DIF analysis on location, economic status, and ICT knowledge.

2.4. Validity and reliability of the instrument

Before proceeding with further analysis, we used the Winsteps software to construct a two-facet (person and item) rating scale model. We constructed a two-facet (person and item) rating scale model for 25 readiness items and 884 respondents using the Rasch model approach. As shown in Table 2, the Person reliability index was obtained as 0.91, which is considered "very good", and an item reliability index of 1.00, which is considered "excellent". The Cronbach's Alpha coefficient value of 0.92 is also considered "very good", indicating that the instrument is very reliable [41], [44], [45].

Table 2 additionally presents the Person separation index (3.16) and item separation index (19.93) of the questionnaire. These indices gauge the questionnaire's ability to differentiate between "Person abilities" concerning the underlying trait, as well as the extent to which the items encompass both the easier and more challenging aspects [42], [44]. A higher separation index increases the probability of respondents providing accurate responses to the items [41]. Nevertheless, it is essential for the separation index to be at least three or greater. Within this study, the questionnaire exhibits an ideal separation index across respondents and items (more than 3), thereby establishing its appropriateness and reliability as a tool for assessing the readiness of Indonesian pre-service science teachers for forthcoming professional challenges. Furthermore, the outfit mean-square statistics for both individuals and items stand at 1.05, corroborated by a significant chi-square score, signifying the model's suitability for the data [44].

Table 2. The summary statistics based on Rasch parameter

	Person	Item
N	884	25
Measure:		
Mean	2.46	0.00
SD	1.37	1.12
Separation	3.16	19.93
Reliability	0.91	1.00
Cronbach's Alpha	0.92	
Chi-squared ($\chi 2$)	22783.2 (df = 21773) **	
Outfit MNSQ:		
Mean	1.05	1.05
SD	0.71	0.30

Note(s): ** p < 0.01

The rating scale analysis used in this study involves a five-frequency rating scale, which means respondents are asked to rate items on a scale with five distinct response options. To assess the quality and effectiveness of this rating scale, the researchers analyzed the separation statistics of the rating criteria, as displayed in Table 3. In Rasch analysis, an important aspect is the distance between the thresholds that separate these rating categories. These thresholds represent the points on the rating scale where a respondent is likely to transition from one response category to another. In this context, it is considered ideal when the distance between these thresholds falls within a specific range, which, in this study, is defined as 1.40 to 5.0 logit, based on previous research [46]. Table 3, included in the study, provides detailed information about the distances between these Rasch-Andrich thresholds for the five rating categories in use. Notably, it is observed that three out of the five ratings align with the ideal values specified earlier (1.40 to 5.0 logit). This alignment indicates that the respondents understood the four-category rating scale quite well when responding to the survey items. In essence, this suggests that the scale effectively captured the nuances of respondents' opinions, and they could differentiate between the various response options. It's crucial to emphasize that the accuracy and the overall quality of the study's results are heavily reliant on the effectiveness of each unit within the rating scale. In other words, having a well-defined and clearly understood rating scale ensures that the data collected accurately represents respondents' perspectives, making the study's findings more reliable and valuable for the research objectives [47].

Table 3. The statistics of rating scale analysis

Category Label	Observed		SE	Rasch-Andrich Threshold
	Count	Frequency %		
1 (Strongly disagree)	136	1	-	None
2 (Disagree)	2136	10	0.11	-0.93
3 (Neutral)	2274	10	0.03	-0.92
4 (Agree)	7284	33	0.02	+0.45
5 (Strongly agree)	10270	46	0.02	+1.40

2. RESULTS AND DISCUSSION

3.1. Pre-service science teachers' readiness for future challenges

In this study, one of the indicators used to see the readiness of pre-service science teachers in facing future challenges is by analyzing item difficulty level based on the logit value of item (LVI). There are five categories of item difficulty based on the logit value of items (LVI) can be referred as; very difficult (Difficulty Level I)), difficult (Difficulty Level II), moderate (Difficulty Level III), easy (Difficulty Level IV) and very easy (Difficulty Level V). The division of the item logit score distribution based on mean and standard deviation was used to classify items into five difficulty strata [42].

Table 4 classifies the items according to their item difficulty level. From Table 4 we can see that there are 0 item (0%) in the difficulty strata I (LVI ≥ Mean logit + 2SD (2.24)), 7 items (28%) in difficulty strata II (0.99 > LVI ≥ 1.98 logit), 3 items (26%) in difficulty strata III (Mean logit + 2SD(2.24) > LVI ≥ 1SD (1.12)), 10 items (12%) in difficulty strata IV (Mean logit (0.00) > LVI ≥ -1SD (-1.12)) and, five items (20%) in difficulty strata V (LVI < -1SD (-1.12)). From the category of perception of the future educator profession, students rated as very easy (Difficulty Level III) to moderate (Difficulty Level V). It means that students have held the belief that in the future they will explore the profession of educator. However, in the

Implementation of learning category, the pre-service science teachers gave a rate from difficult to moderate. This means that students still doubt if learning pedagogy in Indonesia is still relevant to be implemented in the future. And in the Basic skills in the 21st century category, students give easy to very easy scores, which means that students find no difficulty in agreeing that mastering the basic skills of the 21st century (critical thinking, creative thinking, communication and collaboration) is very important.

Table 4. The category of item difficulty based on the logit value of item (LVI)

Task	Difficulty level I, LVI ≥ Mean logit + 2SD (2.24)	Difficulty level II, Mean logit + 2SD (2.24) > LVI ≥ 1SD (1.12)	Difficulty level III, 1SD (1.12) > LVI ≥ Mean logit (0.00)	Difficulty level IV, Mean logit (0.00) > LVI ≥ -1SD (-1.12)	Difficulty level V, LVI < -1SD (-1.12)
Perceptions of the Future Educator Profession (PFEP)	-		PFEP1	PFEP6, PFEP5, PFEP7, PFEP2, PFEP4	PFEP3
Learning Implementation	-	LI1, LI2, LI3, LI4, LI5, LI7, LI9	LI8, LI6		
Basic Skills in the 21st Century	-			BS9, BS2, BS8, BS7, BS1	BS6, BS5, BS3, BS4

Table 5 classifies respondents into four readiness levels for upcoming challenges based on both their demographic profiles and the person logit value (LVP). LVP analysis is used to evaluate the ability categories of prospective science education teachers in accurately answering the given questionnaire [48]–[50]. Based on the mean logit person and SD value, the ability of prospective science education teachers is categorized into very high, high, medium, and low.

Table 5. The category of item difficulty based on the logit value of item (LVI)

Task	Difficulty level I, LVI ≥ Mean logit + 2SD (2.24)	Difficulty level II, Mean logit + 2SD (2.24) > LVI ≥ 1SD (1.12)	Difficulty level III, 1SD (1.12) > LVI ≥ Mean logit (0.00)	Difficulty level IV, Mean logit (0.00) > LVI ≥ -1SD (-1.12)	Difficulty level V, LVI < -1SD (-1.12)
Perceptions of the Future Educator Profession (PFEP)	-		PFEP1	PFEP6, PFEP5, PFEP7, PFEP2, PFEP4	PFEP3
Learning Implementation (LI)	-	LI1, LI2, LI3, LI4, LI5, LI7, LI9	LI8, LI6		
Basic Skills in the 21st Century (BS)	-			BS9, BS2, BS8, BS7, BS1	BS6, BS5, BS3, BS4

Table 6 shows results based on age, where 6 and 30 males are classified as having very high readiness (stemming from their strong self-perceived competence). Furthermore, 70 males and 282 females are classified as having high readiness. Besides, 120 males and 370 females are classified as having medium readiness, and 2 males and 4 females are classified as having low readiness. On the other hand, calculations based on age indicate that 12 people in the age group of 17 - 20 years, 24 in the age group of 20 - 24 years, and 0 in the age group of 25 years and above are classified as having very high readiness. For high readiness, 194 people are in the age group of 17 - 20 years, 150 in the age group of 20 - 24 years, and 8 in the age group of 25 years and above. Additionally, for medium readiness, 244 people are in the age group of 17-20 years, 232 in the age group of 20-24 years, and 14 in the age group of 25 years and above. Lastly, for low readiness, 6 people are in the age group of 17-20 years, 0 in the age group of 20-24 years, and 0 in the age group of 25 years and above.

Next, calculations of type of university show that 34 public university students and 2 private university students have very high readiness, 252 public university students and 100 private university students have high readiness, 416 public university students and 74 private university students have medium readiness, and 2 public university students and 4 private university students have low readiness. Calculations based on the school origin major show that 0 vocational students and 36 non-vocational students have very high readiness, 32 vocational students and 320 non-vocational students have high readiness, 48 vocational students and 442 non-vocational students have medium readiness, and 4 vocational students and 2 non-vocational students have low readiness. Lastly, calculations based on the place of residence show that 8 city residents and 28 district residents have very high readiness, 62 city residents and 290 district residents have high readiness, 158 city residents and 332 district residents have medium readiness, and 0 city residents and 6 district residents have low readiness. Numerous previous studies showed how some majority of pre-service teachers aware about the importance of mastering 21st century skills [36], [51], [52], some also say that 21st-century skills as essential for training prospective teachers to tackle future challenges [37]–[39], [53], [54].

Table 6. Logit value of person analysis

Demographics	Very high, LVP > Mean Logit + 2SD (5.20)	High, Mean Logit + 2SD (5.20) ≤ LVP < Mean Logit (2.46)	Moderate, Mean Logit (2.46) ≥ LVP > Mean Logit - 2SD (-0.28)	Low, LVP < Mean Logit - 2SD (-0.28)
Gender:				
Male	6	70	120	2
Female	30	282	370	4
Age:				
17 - 20 years	12	194	244	6
20 - 24 years	24	150	232	0
25 years and above	0	8	14	0
University type:				
Public	34	252	416	2
Private	2	100	74	4
School origin major:				
Vocational	0	32	48	4
Non-vocational	36	320	442	2
Location:				
City	8	62	158	0
District	28	290	332	6

3.2. Person's differential item functioning (DIF) of students in readiness for future challenges

In this section of the paper, the distinctions among person's differential item functioning (DIF) including location, economic status, and ICT knowledge are presented. And in this paper, DIF analysis is used. DIF analysis can be used to confirm whether there are items that have bias based on the location of residence, economic status, and ICT knowledge that can influence the readiness of prospective science teachers in Indonesia for future challenges, the learning process they receive, and what skills they need. The DIF image based on the location of residence shows in Figure 3.

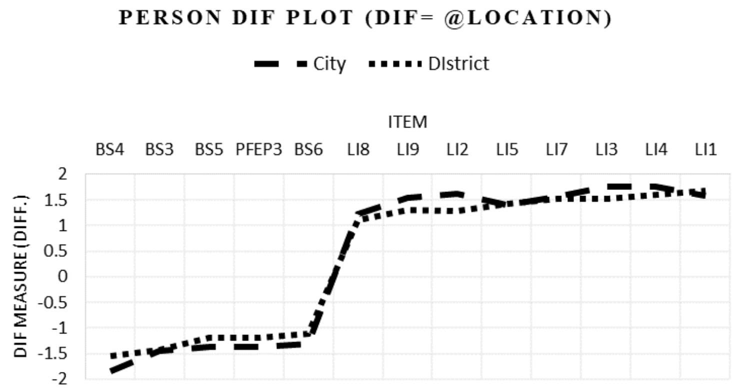

Figure 3. Graph of person DIF based on location

Figure 3 shows that the items BS3, BS4, BS5, BS6, LI1, LI4, LI5, LI7, LI8, and LI9 do not have a DIF based on significant probability and do not have a DIF contrast more than 0.43. However, some items have DIF based on a significant probability, specifically on PFEP3, L2, and L3, in sequence, probabilities are (0.0421), (0.0492), (0.0546) < 0.05. On the other hand, PFEP3, L2, and L3 do not have a DIF contrast more than 0.43 log. Thus, these items fall into the category that can be ignored, and therefore, this instrument is free from bias issues. In Figure 1, the blue line represents respondents residing in cities and the orange line represents respondents residing in districts. It can be seen that there is no significant difference in students' readiness to face future challenges based on location. However, it can also be seen that in LI8, LI9, LI12, LI13, and LI 14 (learning implementation category) pre-service science teachers who live in the city look more ready compared to pre-service science teachers who live in the district. This happens because there is a gap in the quality of education in cities and in rural areas in Indonesia, so students who pursue higher education in cities have better access to education with learning pedagogy that is not old and monotonous [54].

Next, Figure 4 shows the DIF image based on economic status, it shows that the items BS4, BS3, BS6, BS1, BS8, PFEP2, PFEP7 do not have a DIF based on significant probability and do not have a DIF contrast more than 0.43, except on BS3, BS6, PFEP7, with a value of (0.50), (0.48), and (1.52). However, some items have DIF based on significant probability, specifically on BS5, BS7, PFEP1, PFEP3, PFEP4, PFEP5, PFEP6, and LI6, in sequence, probabilities are (0.0213), (0.0317), (0.0291), (0.000), (0.0360), (0.0346), (0.000), (0.0047) < 0.05. On the other hand, items with a DIF contrast more than 0.43 log are BS5 (0.81), PFEP1 (0.62), PFEP3 (0.70), PFEP5 (0.79), PFEP6 (0.99). And those without a DIF contrast more than 0.43 log are BS7, PFEP4, and LI6. Thus, it can be concluded that the items BS5, PFEP1, PFEP3, PFEP5, PFEP6 on this instrument have bias. Bias in the instrument does not mean that the instrument must be removed or replaced, this can be overcome by improving the language at the point of the instrument that contains bias. In this case items BS5, PFEP1, PFEP3, PFEP5, and PFEP6.

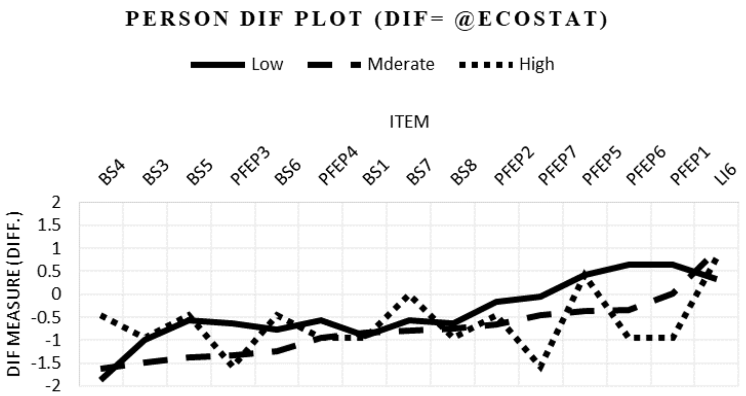

Figure 4. Graph of person dif based on economic status

Person DIF data based on economic status shows that students from high and low economic status have strong readiness to face future challenges. This happens because mostly students with high economic status have privileges and have been prepared earlier to face future challenges, while students with low economic status tend to have strong motivation to improve their quality of life.

Finally, Figure 5 shows the DIF image based on ICT knowledge, it shows that the items BS3, BS9, PFEP1, PFEP7 do not have DIF based on a significant probability, and these items have a DIF contrast more than 0.43 in sequence (1.31), (1.92), (1.06), and (0.71). However, some items have DIF based on a significant probability, specifically on PFEP2, PFEP3, PFEP4, PFEP5, PFEP6, in sequence, probabilities are (0.0139), (0.0132), (0.0177), (0.0008), (0.0014) < 0.05. On the other hand, items with a DIF contrast more than 0.43 log are PFEP2 (4.40), PFEP3 (0.53), PFEP4 (3.65), PFEP5 (2.05), PFEP6 (1.35). Thus, it can be concluded that the items PFEP2, PFEP3, PFEP4, PFEP5, PFEP6 in this instrument have bias. Again, bias in the instrument does not mean that the instrument must be removed or replaced, this can be overcome by improving the language at the point of the instrument that contains bias. In this case items PFEP2, PFEP3, PFEP4, PFEP5, and PFEP6.

Figure 5 provides a surprising picture that students with high ICT knowledge actually have low readiness to face future challenges. To find out the reason for this, further research is needed to see how technology-responsive students' expectations of the learning process. The comprehensive analysis reveals that the results underscore a shared awareness of future challenges and the significance of acquiring 21st-century skills like critical thinking, creative thinking, communication, and collaboration. Nevertheless, the findings also draw attention to a perceived deficiency in the existing learning approaches in adequately nurturing these skills. This highlights the necessity for alternative teaching methods that can cater to diverse backgrounds and effectively cultivate these vital abilities. Further research is required to develop such solutions.

This study successfully provides a more comprehensive understanding of the preparedness of pre-service teachers in Indonesia to tackle future challenges by employing the Rasch analysis approach. The hypothesis is that this deeper insight into pre-service teachers' readiness can aid in formulating more effective learning strategies in higher education institutions, thereby improving the quality of pre-service teachers and better preparing them for future challenges.

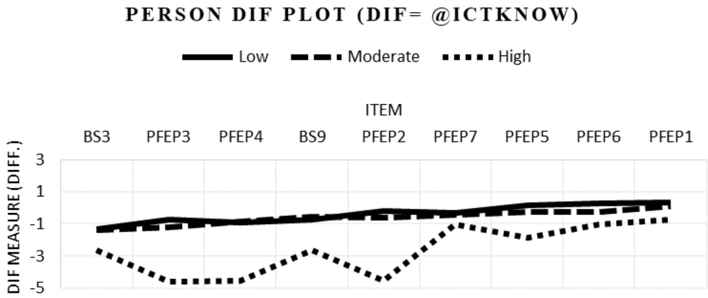

Figure 5. Graph of person DIF based on ICT knowledge

While some research on pre-service science teachers' readiness for Society 5.0 exists, none have explored it in such detail from diverse backgrounds. Some studies focus on single variables, such as educational institution factors [33], [55], [56] or prospective teachers' strengths in specific aspects [34], [57], while others offer a comparative view of Indonesian and Thai teachers' readiness for future challenges [35]. Several prior studies have highlighted that a significant portion of pre-service teachers acknowledge the significance of acquiring proficiency in 21st-century skills, as evidenced by reference [36], [51], [52]. This recognition of the importance of 21st-century skills often sparks discussions within the educational community about how best to integrate these skills into teacher preparation programs and curricula [58]–[60]. Some studies also say that 21st-century skills as essential for training prospective teachers to tackle future challenges [37]–[40], [53]. However, no research has taken a detailed approach to understanding the readiness of pre-service science teachers. Therefore, this research stands as one of the pioneering efforts to use the Rasch analysis approach in comprehending the readiness of pre-service teachers in Indonesia. It has the potential to make significant contributions to the existing literature and offer valuable insights for education policymakers and practitioners.

3. CONCLUSION

The study offers a detailed insight into the preparedness of Indonesian pre-service science teachers for the Society 5.0 era, encapsulating their shared perceptions on future challenges, requisite skills, and prospective learning methods. Drawing from a sizable pool of 884 participants from three primary Indonesian islands, the research employed the Rasch-Andrich model and Differential Item Functioning (DIF) to account for diverse backgrounds. The findings of this study reveal a consensus among pre-service science teachers regarding future challenges. They collectively emphasize the significance of mastering 21st-century skills like critical thinking, creative thinking, communication, and collaboration. Despite this, the present learning approach falls short of nurturing these abilities. Thus, an alternative learning approach that can enhance skills while considering diverse factors such as residence, economic background, and technological prowess is anticipated.

ACKNOWLEDGEMENTS

Additionally, we extend our gratitude to the Directorate General of Higher Education (DGHE) of Indonesia for their generous funding, which made this research possible. Their invaluable support played a pivotal role in facilitating the execution of this study, enabling us to make significant advancements in our understanding of this field and successfully bring it to completion in 2023. Ultimately, this research stands poised to make a substantial contribution to the field of education.

REFERENCES

[1] D. Mourtzis, J. Angelopoulos, and N. Panopoulos, "A Literature Review of the Challenges and Opportunities of the Transition from Industry 4.0 to Society 5.0," *Energies*, vol. 15, no. 17, p. 6276, Aug. 2022, doi: 10.3390/en15176276.
[2] J. Spencer-Keyse, P. Luksha, and J. Cubista, "Learning ecosystems: An emerging praxis for the future of education," *Moscow Sch. Manag. Sk. Glob. Educ. Futur.*, pp. 976–976, 2022, [Online]. Available: https://learningecosystems2020.globaledufutures.org/.

[3] P. S.-C. Goh and N. Abdul-Wahab, "Paradigms to Drive Higher Education 4.0," *Int. J. Learn. Teach. Educ. Res.*, vol. 19, no. 1, pp. 159–171, Jan. 2020, doi: 10.26803/ijlter.19.1.9.
[4] R. C. Anderson, T. Bousselot, J. Katz-Buoincontro, and J. Todd, "Generating Buoyancy in a Sea of Uncertainty: Teachers Creativity and Well-Being During the COVID-19 Pandemic," *Front. Psychol.*, vol. 11, Jan. 2021, doi: 10.3389/fpsyg.2020.614774.
[5] N. A. Rustan, B. Yudi Cahyono, and R. Junaid, "Teachers' perspectives on technology-based learning for the kindergarten students," *J. Educ. Learn.*, vol. 17, no. 3, pp. 374–381, Aug. 2023, doi: 10.11591/edulearn.v17i3.20618.
[6] I. Z. Ichsan *et al.*, "COVID-19 Outbreak on Environment: Profile of Islamic University Students in HOTS-AEP-COVID-19 and PEB-COVID-19," *Tadris J. Kegur. dan Ilmu Tarb.*, vol. 5, no. 1, pp. 167–178, Jun. 2020, doi: 10.24042/tadris.v5i1.6283.
[7] S. Suyatno, W. Wantini, D. I. Pambudi, M. Muqowim, A. Tinus, and L. Patimah, "Developing Pre-Service Teachers' Professionalism by Sharing and Receiving Experiences in the Kampus Mengajar Program," *Educ. Sci.*, vol. 13, no. 2, p. 143, Jan. 2023, doi: 10.3390/educsci13020143.
[8] L. Yang, F. Martínez-Abad, and A. García-Holgado, "Exploring factors influencing pre-service and in-service teachers´ perception of digital competencies in the Chinese region of Anhui," *Educ. Inf. Technol.*, vol. 27, no. 9, pp. 12469–12494, Nov. 2022, doi: 10.1007/s10639-022-11085-6.
[9] M. Riad, M. Qbadou, E.-S. Aoula, and S. Gouraguine, "The new e-learning adaptation technique based on learner's learning style and motivation," *J. Educ. Learn.*, vol. 17, no. 3, pp. 472–482, Aug. 2023, doi: 10.11591/edulearn.v17i3.20826.
[10] E. G. Carayannis and J. Morawska-Jancelewicz, "The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities," *J. Knowl. Econ.*, vol. 13, no. 4, pp. 3445–3471, Dec. 2022, doi: 10.1007/s13132-021-00854-2.
[11] C. Narvaez Rojas, G. A. Alomia Peñafiel, D. F. Loaiza Buitrago, and C. A. Tavera Romero, "Society 5.0: A Japanese Concept for a Superintelligent Society," *Sustainability*, vol. 13, no. 12, p. 6567, Jun. 2021, doi: 10.3390/su13126567.
[12] Irwandani *et al.*, "Bibliometric analysis trend of computational thinking research in physics: Thinking skills to support environmental sustainability for elementary and high schools," *AIP Conf. Proc.*, vol. 2595, 2023, doi: 10.1063/5.0124196.
[13] A. T. Rokhayati Rosa and M. Mujiarto, "Teacher Development Potential (Creativity and Innovation) Education Management in Engineering Training, Coaching and Writing Works through Scientific Knowledge Intensive Knowledge Based on Web Research in the Industrial Revolution and Society," *Int. J. High. Educ.*, vol. 9, no. 4, p. 161, Jun. 2020, doi: 10.5430/ijhe.v9n4p161.
[14] S. K. Bartolic *et al.*, "A multi-institutional assessment of changes in higher education teaching and learning in the face of COVID-19," *Educ. Rev.*, vol. 74, no. 3, pp. 517–533, Apr. 2022, doi: 10.1080/00131911.2021.1955830.
[15] R. Amalia, M. Zaiyar, F. Fadilah, and E. Santoso, "Android-Based Learning Environment To Enhance Creative Thinking Mathematics and Self-Efficacy," *J. Phys. Conf. Ser.*, vol. 1764, no. 1, p. 012133, Feb. 2021, doi: 10.1088/1742-6596/1764/1/012133.
[16] R. E. Prasetya, A. Sekretari, and B. Luhur, "The design of Moodle-based English language learning environments (case study of Indonesian higher education)," *ELT Worldw. J. English Lang. Teach.*, vol. 8, no. 2, pp. 222–239, 2021, [Online]. Available: https://ojs.unm.ac.id/ELT/article/view/19934.
[17] S. Syaharuddin, M. Mutiani, M. R. N. Handy, E. W. Abbas, and J. Jumriani, "Putting transformative learning in higher education based on linking capital," *J. Educ. Learn.*, vol. 16, no. 1, pp. 58–64, Feb. 2022, doi: 10.11591/edulearn.v16i1.20373.
[18] Z. Sakhiyya and T. Wijaya Mulya, "Introduction: Education in Indonesia—A Critical Introduction," 2023, pp. 1–14.
[19] L. Lomba-Portela, S. Domínguez-Lloria, and M. R. Pino-Juste, "Resistances to Educational Change: Teachers' Perceptions," *Educ. Sci.*, vol. 12, no. 5, p. 359, May 2022, doi: 10.3390/educsci12050359.
[20] N. Mospan, "Trends in emergency higher education digital transformation during the COVID-19 pandemic," *J. Univ. Teach. Learn. Pract.*, vol. 20, no. 1, pp. 50–70, Jan. 2022, doi: 10.53761/1.20.01.04.
[21] I. Jahidi, R. Y. Okky, D. Indrawati, G. Permana, and I. Setiawan, "Governance Model for Higher Education in Indonesia Post-Pandemic of Covid-19 Towards a New Normal Era," *J. High. Educ. Theory Pract.*, vol. 23, no. 6, pp. 177–184, 2023, doi: 10.33423/jhetp.v23i6.5965.
[22] C. S. Chai, Y. Rahmawati, and M. S.-Y. Jong, "Indonesian Science, Mathematics, and Engineering Preservice Teachers' Experiences in STEM-TPACK Design-Based Learning," *Sustainability*, vol. 12, no. 21, p. 9050, Oct. 2020, doi: 10.3390/su12219050.
[23] L. Auni, T. Zulfikar, S. Akmal, A. Alfiatunnur, and F. Dina, "International Teaching Internship: Development of Pre-Service Teachers' Competences," *Qual. Rep.*, Dec. 2022, doi: 10.46743/2160-3715/2022.5457.
[24] T. Ahmad, R. Madonski, D. Zhang, C. Huang, and A. Mujeeb, "Data-driven probabilistic machine learning in sustainable smart energy/smart energy systems: Key developments, challenges, and future research opportunities in the context of smart grid paradigm," *Renew. Sustain. Energy Rev.*, vol. 160, p. 112128, May 2022, doi: 10.1016/j.rser.2022.112128.
[25] A. Saykili, "Higher Education in The Digital Age: The Impact of Digital Connective Technologies," *J. Educ. Technol. Online Learn.*, vol. 2, no. 1, pp. 1–15, Jan. 2019, doi: 10.31681/jetol.516971.
[26] T. Ahmad, "Scenario based approach to re-imagining future of higher education which prepares students for the future of work," *High. Educ. Ski. Work. Learn.*, vol. 10, no. 1, pp. 217–238, Dec. 2019, doi: 10.1108/HESWBL-12-2018-0136.
[27] H. Tinmaz, Y.-T. Lee, M. Fanea-Ivanovici, and H. Baber, "A systematic review on digital literacy," *Smart Learn. Environ.*, vol. 9, no. 1, p. 21, Dec. 2022, doi: 10.1186/s40561-022-00204-y.
[28] H. Pötzsch, "Critical Digital Literacy: Technology in Education Beyond Issues of User Competence and Labour-Market Qualifications," *tripleC Commun. Capital. Crit. Open Access J. a Glob. Sustain. Inf. Soc.*, vol. 17, no. 2, pp. 221–240, Aug. 2019, doi: 10.31269/triplec.v17i2.1093.
[29] W. H. Prasetiyo, B. I. Sari, Patmisari, H. Sa'diyah, N. B. M. Naidu, and E. Prasetyo, "Using Rasch model analysis for assessing psychometric properties of digital citizenship in Indonesian students," *J. E-Learning Knowl. Soc.*, vol. 18, no. 3, pp. 96–110, 2022, doi: 10.20368/1971-8829/1135684.
[30] S. Sovey, K. Osman, and M. E. E. M. Matore, "Gender differential item functioning analysis in measuring computational thinking disposition among secondary school students," *Front. Psychiatry*, vol. 13, Nov. 2022, doi: 10.3389/fpsyt.2022.1022304.
[31] B. Sumintono and W. Widhiarso, *Application of Rasch Modeling in Educational Assessment*. (in Indonesian) Bandung: Trim Komunikata, 2015.
[32] P. S. Trantham, J. Sikorski, R. J. de Ayala, and B. Doll, "An item response theory and Rasch analysis of the NUDKS: a data literacy scale," *Educ. Assessment, Eval. Account.*, vol. 34, no. 1, pp. 113–135, Feb. 2022, doi: 10.1007/s11092-021-09372-w.
[33] A. Ilhami, D. Diniya, S. Susilawati, and R. Vebrianto, "Digital Literacy of Pre-Service Science Teachers as Reflection of Readiness Toward Online Learning in New Normal Era," *THABIEA J. Nat. Sci. Teach.*, vol. 4, no. 2, p. 207, Dec. 2021, doi: 10.21043/thabiea.v4i2.9988.
[34] R. A. Pratama, M. A. Saputra, I. M. Pratiwi, and N. I. Lestari, "Student Teachers's Readiness to Face Society 5.0 Challenges: Are

They Ready to Teach with Competencies Needed?," 2022, doi: 10.2991/assehr.k.220102.061.
[35] R. A. Z. El Islami and P. Nuangchalerm, "Comparative study of scientific literacy: Indonesian and Thai pre-service science teachers report," *Int. J. Eval. Res. Educ.*, vol. 9, no. 2, p. 261, Jun. 2020, doi: 10.11591/ijere.v9i2.20355.
[36] L. Studies and H. Bedir, "Pre-service ELT teachers' beliefs and perceptions on21st century learning and innovation skills (4Cs)," *J. Lang. Linguist. Stud.*, vol. 15, no. 1, pp. 231–246, 2019.
[37] K. Liza and E. Andriyanti, "Digital literacy scale of English pre-service teachers and their perceived readiness toward the application of digital technologies," *J. Educ. Learn.*, vol. 14, no. 1, pp. 74–79, Feb. 2020, doi: 10.11591/edulearn.v14i1.13925.
[38] R. Metruk, "Confronting the Challenges of MALL: Distraction, Cheating, and Teacher Readiness," *Int. J. Emerg. Technol. Learn.*, vol. 15, no. 02, p. 4, Jan. 2020, doi: 10.3991/ijet.v15i02.11325.
[39] A. Rusilowati and B. Subali, "Preparing 21st century teachers: Implementation of 4C character's pre-service teacher through teaching practice," 2019, doi: 10.1088/1742-6596/1233/1/012109.
[40] P. K. Jha, "ICT for pre-service and in-service teachers: Implications and challenges," *Teach. Educ. Gener. Next Perspect. Oppor. Challenges*, pp. 160–167, 2021.
[41] T. G. Bond and C. M. Fox, *Applying the Rasch Model: Fundamental Measurement in the Human Sciences*, 3rd Ed. Mahwah, New Jersey: Erlbaum, 2015.
[42] D. Adams, K. M. Chuah, B. Sumintono, and A. Mohamed, "Students' readiness for e-learning during the COVID-19 pandemic in a South-East Asian university: a Rasch analysis," *Asian Educ. Dev. Stud.*, vol. 11, no. 2, pp. 324–339, Mar. 2022, doi: 10.1108/AEDS-05-2020-0100.
[43] D. Andrich and I. Marais, "A Course in Rasch Measurement Theory," in *Springer Texts in Education*, Springer Singapore, 2009.
[44] W. J. Boone, M. S. Yale, and J. R. Staver, "Rasch analysis in the human sciences," *Rasch Anal. Hum. Sci.*, pp. 1–482, 2014, doi: 10.1007/978-94-007-6857-4.
[45] J. M. Linacre, "Rating scale instrument quality criteria," *Rasch Meas. Trans.*, 2018, [Online]. Available: https://www.rasch.org/rmt/rmt211m.htm.
[46] C. Van Zile-Tamsen, "Using Rasch Analysis to Inform Rating Scale Development," *Res. High. Educ.*, vol. 58, no. 8, pp. 922–933, Dec. 2017, doi: 10.1007/s11162-017-9448-0.
[47] J. M. Linacre, "A user's guide to Winsteps Ministeps Rasch-model computer programs," *Winsteps*, 2013. .
[48] S. W. Chan, C. K. Looi, and B. Sumintono, "Assessing computational thinking abilities among Singapore secondary students: a Rasch model measurement analysis," *J. Comput. Educ.*, vol. 8, no. 2, pp. 213–236, 2021, doi: 10.1007/s40692-020-00177-2.
[49] S.-W. Chan, C.-K. Looi, W. K. Ho, W. Huang, P. Seow, and L. Wu, "Learning number patterns through computational thinking activities: A Rasch model analysis," *Heliyon*, vol. 7, no. 9, p. e07922, Sep. 2021, doi: 10.1016/j.heliyon.2021.e07922.
[50] S. Soeharto and B. Csapó, "Assessing Indonesian student inductive reasoning: Rasch analysis," *Think. Ski. Creat.*, vol. 46, p. 101132, Dec. 2022, doi: 10.1016/j.tsc.2022.101132.
[51] T. Valtonen *et al.*, "How pre-service teachers perceive their 21st-century skills and dispositions: A longitudinal perspective Teemu," *Comput. Human Behav.*, vol. March 2021, p. 106643, 2020, doi: 10.1016/j.chb.2020.106643.
[52] S. K. Howard, J. Tondeur, J. Ma, and J. Yang, "What to teach? Strategies for developing digital competency in preservice teacher training," *Comput. Educ.*, vol. 165, p. 104149, May 2021, doi: 10.1016/j.compedu.2021.104149.
[53] A. List, E. W. Brante, and H. L. Klee, "A framework of pre-service teachers' conceptions about digital literacy: Comparing the United States and Sweden," *Comput. Educ.*, vol. 148, p. 103788, Apr. 2020, doi: 10.1016/j.compedu.2019.103788.
[54] A. N. Hasudungan, Ofianto, and T. Z. Ningsih, "Learning Loss: A Real Threat in Education for Underprivileged Students and Remote Regions during the Covid-19 Pandemic," *Int. J. Distance Educ. E-Learning*, vol. 7, no. 1, pp. 12–23, Jan. 2022, doi: 10.36261/ijdeel.v7i1.2223.
[55] T. Güner and S. Aslan, "An Analysis of the Relationship Between the Pre-Service Teachers' Curriculum Literacy and Their Preparedness to Teach," *Anadolu Üniversitesi Eğitim Fakültesi Derg.*, vol. 7, no. 1, pp. 111–126, Jan. 2023, doi: 10.34056/aujef.1177806.
[56] M. A. A. Bahtaji, "Pre-service Science Teachers' Emphases and Views about Science Education Curriculum," *Int. J. Instr.*, vol. 16, no. 1, pp. 919–932, Jan. 2023, doi: 10.29333/iji.2023.16151a.
[57] R. B. Batchar and G. D. Abad, "Pre-Service Teachers' Environmental Literacy and Readiness Towards Environmental Education," *Int. J. Innov. Sci. Res. Rev.*, vol. 05, pp. 4185–4195, 2023, [Online]. Available: http://www.journalijisr.com.
[58] T. Valtonen *et al.*, "Examining pre-service teachers' Technological Pedagogical Content Knowledge as evolving knowledge domains: A longitudinal approach," *J. Comput. Assist. Learn.*, vol. 35, no. 4, pp. 491–502, Aug. 2019, doi: 10.1111/jcal.12353.
[59] J. Tondeur, R. Scherer, F. Siddiq, and E. Baran, "Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK): a mixed-method study," *Educ. Technol. Res. Dev.*, vol. 68, no. 1, pp. 319–343, Feb. 2020, doi: 10.1007/s11423-019-09692-1.
[60] L. Manasia, M. G. Ianos, and T. D. Chicioreanu, "Pre-service teacher preparedness for fostering education for sustainable development : An empirical analysis of central dmensions of teaching readiness," *Sustainability*, vol. 12, no. 1, pp. 4–6, 2020.

BIOGRAPHIES OF AUTHORS

Irwandani Irwandani is a doctoral student in the Department of Education, Faculty of Teacher Training and Education, Universitas Lampung, Indonesia. In addition to his studies, he is also actively teaching in the Physics Education Program, Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Raden Intan Lampung, Indonesia. His research focus is in the field of education, particularly physics education, teacher professional development, learning media, and 21st-century skills. He can be contacted at email: irwandani@radenintan.ac.id.

Agus Suyatna is a professor in the field of Departmen of Science Education at the Faculty of Teacher Training and Education, Universitas Lampung, Indonesia. His research areas include science education, science teaching and learning, physics education, scientific literacy, technology in education, and STEM education. Currently, he is actively teaching in the Doctoral Education Program, Master's Program in Physics Education, and undergraduate physics education program at the Universitas Lampung. He can be contacted at email: agus.suyatna@fkip.unila.ac.id.

Een Yayah Haenilah is a professor in the field of curriculum development at the Faculty of Teacher Training and Education, Universitas Lampung, Indonesia. She is actively involved in teaching in the doctoral student in Department of Education Program and Department of Elementary Education at the Universitas Lampung. Her research focus is in the field of education, particularly curriculum development, pedagogical development, teacher professional development, and learning strategies. She can be contacted at email: een.yayahhaenilah@fkip.unila.ac.id.

Dina Maulina is an assistant professor in the Department of Biology Education at the Faculty of Teacher Training and Education, Universitas Lampung. She is also actively involved in teaching in the doctoral students at Department of Education at the same university. Her research focuses on biology education and teaching, learning media, teacher professional development, and biological sciences. She can be contacted at email: dina.maulina@fkip.unila.ac.id.