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Research Article

Measuring mathematics and science teachers' perception on thinking and acting in 21st-century learning

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Abstract

The purpose of this study was measured the Islamic university mathematics and science teachers (IU-MSTs) perception on thinking and acting in 21st-century learning (TA21stCL). An explanatory sequential mixed method design was used to conduct the study. Data were collected by using TA21stCL questionnaires. The TA21stCL questionnaire contains 16 indicators and 42 statements that consists of critical thinking (CritT), problem-solving (PS), creativity (Creat), and metacognition (Metacog), communicating (Comm), debating (Deb), collaborating (Col), digital literacy (DL), and technological literacy (TL). Data were obtained from a total of thirty-one IU-MSTs (the subjects taught include math= 9, bio= 11, physics=8 and chemistry=3) that have taught at Islamic universities located in the province of West Sumatra, Indonesia. To complete the findings, participants were asked to answer several questions about the application of 21st century skills in the learning process. Based on the ANOVA and Scheffe tests, the differences in teacher perceptions based on teaching subject (TS) were found on the technology literacy factor (TechLit) with a score of 4,146 * at p<.05 and 2.59 in the preferred teaching. The finding of the study showed that Islamic university mathematics and science teachers (IU-MSTs) stated that problem-solving (PS), creativity (Creat), and technology literacy (TechLit) skills as 21st century skill were important competencies to be mastered at Islamic university. This finding showed that the 21st century skill were important competencies to be mastered at Islamic university. In other words, the most important competencies to be mastered by students in Islamic University, on thinking skills was problem-solving (PS) and creativity (Creat), and on acting was technology literacy (TechLit). This study also recommends the use variaty of learning methods in 21st century learning to equip students with problem-solving (PS) and creativity (Creat) and Technological literacy (TechLit) skills.

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Introduction

Over the past two decades, educators have determined strategies to prepare students on how to navigate through the increasingly globalized world and inter-connected landscape associated with the 21st century (Teo, 2019). Students need helpful skills in order to deal with the competitive global changes, which are needed by students to prepare themselves after graduating from college (Kaufman, 2013; Larson & Miller, 2011). Previous studies stated that many 21st century skills are needed by students such as problem-solving (Idawati et al. 2020; Amin et al. 2020; Son & Lee, 2020; Tursucu et al. 2020; Al-Hilli, 2019; Herde et al. 2016), critical thinking (Nur et al. 2020; Tiruneh et al. 2018; Tiruneh et al. 2017; Suwono et al. 2017), metacognition (Al Gaseem at al. 2020; Tachie, 2019; Listiana et al. 2016), creativity (Salehudin, 2019; Lucas, 2016; Ercikan & Olivery, 2016), computer and information literacy (Ainley et al. 2016; Fry & Seely, 2011). This explanation also shows that TA21stCL was hot topics which require adequate studies related to mastering mathematics or science (Geisinger, 2016).

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Previous studies investigated the use of teaching strategies and determine the factors associated with learning mathematics and science. Kan'an (2018) determined the relationship between Jordanian students' 21st-century skills (Cs21) and academic achievement in science and found that female urban students performed better compared to their rural male counterpart. In others, the students' generic science skills are considered part of their 21st-century skills (Haviz et al. 2018). Teachers' actual and preferred perception of twenty-first century learning competencies in China was also conducted by Sang et al. (2018). The findings of the study showed that an opportunity to investigate TA21STCL with a variety of teaching subject, preferred and actual teaching.

According to Greenstein (2012), the TA21STCL framework was formed from thinking, acting and living (TAL). The thinking skills consist of critical, problem-solving, creativity, and metacognition (Greenstein, 2012), which are used for their development (Unver, 2015). Critical thinking is associated with any subject, content, or problem where the participants skillfully improve the quality of their thinking by skillfully taking over the structure inherent and imposing intellectual standards (Elder, 2007). In line with this, Greenstein (2012) also stated that critical thinking includes the concept of analyzing information, applying strategies, ideas, logical inquiry, making conclusions, evaluating evidence, accurate judgments, and analyzing assumptions.

In accordance with this, several articles on critical thinking have been conducted by Wartono et al. (2018). This study shows that there are 5 indicators of critical thinking skills of high school students, namely basic clarification, support, conclusions, further clarifications, and strategies. In another article, it showed that the analysis, evaluation, inference, interpretation, explanation, and organization were used to determine students' critical thinking skills (Duran & Dökme, 2016).

This is followed by the problem-solving skill, which is a basic process for identifying problems, considering informed choices, making/implementing plans, and evaluating the results (Greenstein, 2012). The third thinking skill is creativity which is mastered by students (Bakır & Öztekin, 2014). Its characteristics are as follows (a) curiosity, such as probing, asking questions, searching for deeper meaning, (b) fluency, such as the production of a number of ideas, (c) originality, which consists of fresh, unique or unusual ideas, (d) elaboration, such as ideas that display intensive details or add to existing details, (e) imagination, e.g. dreaming, discovering new ideas or products, ingenuity and (f) flexibility of various possibilities (Greenstein, 2012). Sener and Tas (2017) stated that there is a significant difference between the test scores of the creative and control groups when compared before and after the teaching process.

The fourth thinking skill is metacognition which includes knowledge and process basis (Damar et al. 2015). According to Greenstein (2012), in the classroom, this skill is directed, conscious, self-regulated and flexible. Students 'metacognitive abilities have been investigated by previous researchers, such as the implementation of group integrated with the teaching strategy that maximizes the empowerment of students' skills (Listiana et al. 2016), which contribute to cognitive learning outcomes far greater than the contribution of learning motivation (Bahri & Corebima, 2015).

Greenstein (2012) stated that acting is divided into communication, collaborative, digital, visual, and technology literation. According to Common Core State Standards Initiative (2011) communication skills have been identified in education practice, such as (a) identifying and using various types of verbal communication such as conversation, debate, and persuasion, (b) engaging in constructive dialogue with others, (c) demonstrating effective communication skills by paying attention, listening reflectively and comprehending, (d) identifying, using and understanding various types of formal, informal and scientific written communication, (e) reading, viewing, and listening to multiple types of media for various purposes, (f) producing effective communication through multiple media, such as oral, written, visual, nonverbal and technological and (g) using persuasively communication to express views and preferences in neutral manner.

The second acting skill is collaborative, which includes active listening skills, responding with respect, expressing ideas clearly through various communication channels, and using these skills to reach consensus and compromise (Greenstein, 2012). This is followed by the acting skills, which are digital literation, visual and technology. According to Greenstein (2012), digital literacy is concerned with finding, using, selecting, evaluating, and visual literacy developing when new forms of images emerge. It has multiple meanings, referring to the understanding and production of digital images. Furthermore, it involves interpreting, expressing ideas, communicating through images, evaluating, choosing and using appropriate tools with visual concepts and models.

According to the decision of the Directorate General of Islamic Education Ministry of Religion of the Republic of Indonesia Number 2498 in year 2019, integrated learning was a characteristic of studying Islamic university in Indonesia. Previously, this integrated instruction was developed independently by each Islamic university in Indonesia. Since 2016, IAIN Batusangkar Indonesia also implemented integrated learning. The application of Integrated

instruction during the learning process refers to the university's integrative learning guidelines. The application of this integrated learning improves student skills and learning outcomes. For example, research conducted by Haviz (2016) and Haviz et al. (2012). Both studies have integrated embryology with the Quran at Islamic universities. Although with different content, research conducted by Zainuddin & Perera (2017) and Holland & Piper (2014) are integrated instruction researches on their respective content. For example, Zainuddin & Perera (2017) identified the differences between a flipped classroom and a non-flipped classroom instructional model, and the results of the study showed that the out of class activities included the sharing of short video clips uploaded on to the institutional learning management system for students' access before class had successfully established the basic psychological needs of self-determination theory.

However, a clear gap found in the application of integrated learning in Islamic universities is not yet clearly determined the type of skills needed by students. If it is related to the application in class, there are not many reports of studies on the application and type of skills needed by students. So, this study conducted to measure the perception on thinking and acting in 21st-century learning (TA21stCL) post the implementation of integrated learning by Islamic university mathematics and science teachers (IU-MSTs).

The purpose of this study was measured the Islamic university mathematics and science teachers (IU-MSTs) perception on thinking and acting in 21st-century learning (TA21stCL). The perception of IU-MSTs measure based on (a) teaching subject (TS) on the TA21stCL factor and (b) actual and preferred teaching with the TA21stCL factor.

Method

Research Design

An explanatory sequential mixed method design (Creswell, 2014) was used to conduct the study. In this study, quantitative findings are followed by qualitative findings, and both findings are strengthened by a more comprehensive explanation. Thus, this study expects the study outcomes of deep understanding or a more in-depth understanding of quantitative data.

Participants

Data were obtained from a total of thirty-one IU-MSTs (the subjects taught include math= 9, bio= 11, physics=8 and chemistry=3) that have taught at Islamic universities located in the province of West Sumatra, Indonesia. These IU-MSTs were within the ages of 27-52 years old with an average age of *M*=32.25 and consist of 24 women and 7 men. Furthermore, a total of 6 and 23 lecturers are doctorate and masters' degree holders, respectively.

Data Collection Tools

Data were collected by using thinking and acting in 21st-century learning (TA21stCL) printed questionnaires. The TA21stCL questionnaire contains 16 indicators and 42 statements that constructed from Greenstein (2012). The thinking skill consists of critical thinking (CritT), problem-solving (PS), creativity (Creat), and metacognition (Metacog), while the acting skills consist of communicating (Comm), debating (Deb), collaborating (Col), digital literacy (DL), and technological literacy (TL). This questionnaire has a rating scale of 1-4, with the following details. Level 1: emerging tier = 2.0 to 2.7 (initial, beginner, bad, serious error, incomplete), level 2: ability = 2.8 to 3.1 (developing, basic, fair, some misunderstanding, partially), level 3: skill = 3.2 to 3.5 (achieved, competent, good, fulfilling the requirements, mostly complete), level 4: top-level = 3.6 to 4.0 (exemplary, advanced, outstanding, beyond requirements, completely complete). To complete the findings, participants were asked to answer several questions about the application of 21st century skills in the learning process. The question was developed from the findings of previous studies.

Validity and Reliability

The validity and reliability tests used the CFA and alpha Cronbach methods to determine the goodness and structure of the instrument used for the research data collection. For the TA21STCL questionnaire, the CFA test results on 9 factors namely Critical Thinking (CriT), Problem Solving (PS), Creativity (Creat), Meta Cognition (MetaCog), Communication (Comm), Debate (Deb), Collaborating (Coll), Digital Literacy (DigLit) show that the instrument was valid. From the data obtained, the validity score is in the range of 0.0 - 1.71. These results also show that the pattern/structure coefficients for TA21STCL are above 0.1 (see Table 1). The result of alpha Cronbach .923, N=42.

Data Analysis

ANOVA test was used to determine differences IU-MSTs perceptions based on TS on the factor of TA21stCL. T-test was used to determine IU-MSTs perceptions of actual and preferred teaching with the factor of TA21stCL.

Results

The results of studies on IU-MSTs perceptions based on teaching subject (TS) on the TA21stCL factor are shown in Table 2. In the mathematics subject, the lowest score of 2.21 (1.10), is found in the debating skill of the actual teaching. Meanwhile, the highest score of 3.74 (0.65) is in communication skill. In biology, the lowest score of 2.94 (0.31), was found in critical thinking skills, of actual teaching, while the highest was in the communication skills at3.89 (0.33) and 3.89 (0.55) is preferred and actual teaching. The score is also found in the collaborative skills, which is 3.89 (0.25), and in the preferred teaching. In physics, the lowest and highest scores were found in the debating and literacy skill, at 2.11 (0.65), and in 4.25 (0.45), respectively. In chemistry, the lowest and highest scores were found in the debating skill, at 2.67 (1.36), and 4.08 (0.14), respectively.

Based on the ANOVA and Scheffe tests, the differences in teacher perceptions based on teaching subject (TS) were found on the technology literacy factor (TechLit) with a score of 4,146 * at P <.05 and 2.59 in the preferred teaching. However, no differences were found in the critical thinking (CriT), problem-solving (PS), creativity (Creat), meta-cognition (MetaCog), communication (Comm), debate (Deb), collaboration (Coll) and digital literacy (DigLit).

The results of the studies on the differences in IU-MSTs perceptions with actual and prefered teaching on the TA21stCL factor are shown in Table 3. These findings showed that the differences in average scores and standard deviations between actual and preferred teaching are only found in Critical Thinking (CritT) and Problem Solving (PS) factors. In the Critical Thinking (CritT) factor, the average score and standard deviation are 3.12 (0.56), with a mean score and standard deviation of 3.68 (0.47). The t-test score was found to be -3,959 ** and different at P <.01. Cohen's d test scores were found to be 1.0980. Furthermore, in the Problem Solving (PS) factor, the average score and standard deviation are found to be 3.14 (0.43), and 3.47 (0.52). The t-test score was found to be -2,496 ** and significantly different at P <.01, with a Cohen's d test scores of 0.6923.

Then, the result about application of 21st century skills in the learning process with qualitative interview wrote on Table 4. These finding showed that three question has answer by IU-MSTs with variety answers. For example, the question *"How is the application of critical thinking in the learning process"* has answer by IU-MSTs with *"I consistently demonstrate multiple skills when conducting evaluation, analysis and synthesis in the learning process"*. The question *"How is the application of problem solving in the learning process?"* has answer by IU-MSTs with *"I apply problem solving skills (problem solving skills) in various learning situations"*. The question *"How is the using information communication technology"* has answer by IU-MSTs with *"I understand and use media and communication and information technology (ICT) to design or create quality learning products"*.

Table 1.

Pattern/ Structure Coefficients for Factor TA21stCL

	Factor 1: Critical thinking (CriT)		Factor 2: Problem Solving (PS)		Factor 3: Creativity (Creat)		Factor 4: Meta Cognition (MetaCog)		Factor 5: Commu-nication (Comm)		Factor 6: Debate (Deb)		Factor 7: Colla-borating (Coll)		Factor 8: Digital Literacy (DigLit)		Factor 9: Technology Literacy (TechLit)	
	A	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**
CritT 1	0.91	0.39																
CritT 2	0.89	0.74																
CritT 3	0.51	0.04																
CritT 4	0.44	0.66																
PS 1			0.00	0.31														
PS 2			0.20	0.12														
PS 3			0.36	0.66														
PS 4			1.71	1.07														
PS 5			0.36	0.66														
Creat 1					0.81	0.67												
Creat 2					0.74	0.78												
Creat 3					0.81	0.83												
Creat 4					0.79	0.75												
Creat 5					0.80	0.68												
Creat 6					0.70	0.90												
Creat 7					0.84	0.74												
Creat 8					0.73	0.73												
Creat 9					0.70	0.81												
MetaCog 1							0.37	0.50										
MetaCog 2							0.81	0.85										
MetaCog 3							0.86	0.82										
Com 1									0.90	0.90								
Com 2									0.90	0.90								
Deb 1											0.89	0.87						
Deb 2											0.90	0.97						
Deb 3											0.84	0.91						
Deb 4											0.85	0.92						
Deb 5											0.96	0.95						
Deb 6											0.94	0.89						
Coll 1													0.98	1.00				
Coll 2													0.94	0.88				
Coll 3													0.85	0.80				
Coll 4													0.86	0.95				
DigLit 1															0.67	0.49		
DigLit 2															0.84	0.77		
DigLit 3															0.91	1.04		
DigLit 4															0.92	0.77		
TechLit 1																	0.75	0.79
TechLit 2																	0.91	1.00
TechLit 3																	0.79	0.74
TechLit 4																	0.96	0.86
TechLit 5																	0.87	0.74

Tabel 2.

IU-MSTs Perceptions based on Teaching Subject (TS) on the TA21stCL Factor

TA21stCL	CriT (M, SD)		PS (M, SD)		Creat (M, SD)		MetaCog (M, SD)		Comm (M, SD)		Deb (M, SD)		Coll (M, SD)		DigLit (M, SD)		Tech Lit (M, SD)	
	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P
Math	3.28 (0.71)	3.63 (0.48)	3.23 (0.51)	3.50 (0.64)	2.90 (1.21)	2.92 (1.25)	3.00 (1.04)	3.34 (1.08)	3.31 (0.88)	3.75 (0.65)	2.21 (1.10)	2.42 (1.16)	2.69 (1.07)	3.34 (1.06)	2.91 (0.92)	3.22 (1.08)	2.58 (0.84)	2.80 (0.99)
Bio	2.94 (0.39)	3.78 (0.36)	3.13 (0.33)	3.73 (0.33)	2.95 (0.31)	3.58 (0.27)	3.41 (0.28)	3.63 (0.39)	3.89 (0.33)	3.89 (0.55)	3.15 (0.82)	3.33 (0.98)	3.61 (0.36)	3.89 (0.25)	3.44 (0.53)	3.86 (0.47)	2.98 (0.24)	3.36 (1.09)
Phys	2.92 (0.47)	3.63 (0.70)	3.07 (0.45)	3.10 (0.55)	3.05 (0.36)	3.54 (0.63)	2.45 (1.05)	2.50 (1.09)	3.42 (1.28)	3.67 (1.51)	2.20 (0.69)	2.11 (0.65)	3.04 (1.63)	3.04 (1.63)	4.17 (0.47)	4.25 (0.45)	3.93 (0.84)	4.03 (0.88)
Chemist	3.58 (0.52)	3.67 (0.38)	3.07 (0.61)	3.33 (0.23)	3.00 (0.33)	3.22 (0.19)	3.33 (0.58)	3.44 (0.51)	3.67 (0.29)	3.83 (0.29)	2.67 (1.36)	2.83 (1.45)	3.75 (0.66)	4.08 (0.14)	3.83 (0.76)	4.00 (0.50)	3.20 (0.53)	3.20 (0.53)
F (Anova)	1.58	0.17	0.18	2.06	0.05	1.2	1.84	2.23	0.8	0.09	1.81	2.00	1.48	1.28	4.146*	2.59	3.03	1.86
Scheffe test															(1) < (3)			

* P<.05, **P<.01, M = Mean, SD = Standar Deviation

Table 3.

The Differences in IU-MSTs Perceptions with Actual and Prefered Teaching on the TA21stCL Factor

	CriT (M, SD)	PS (M, SD)	Creat (M, SD)	Metacog (M, SD)	Comm (M, SD)	Deb M, SD)	Coll (M, SD)	DigLit (M, SD)	TechLit (M, SD)
Actual	3.12 (0.56)	3.14 (0.43)	2.97 (0.69)	3.05 (0.85)	3.58 (0.81)	2.58 (0.996)	3.21 (1.06)	3.49 (0.80)	3.10 (0.95)
Prefered	3.68 (0.47)	3.47 (0.52)	3.32 (0.8)	3.26 (0.91)	3.79 (0.83	2.71 (1.09)	3.55 (1.01)	3.77 (0.79)	3.32 (1.02)
t test	-3.959**	-2.496**	-1.733	-0.845	-0.933	-0.442	-1.175	-1.263	-0.817
Cohen's d	1.0980	0.6923	0.4806	0.2344	0.2588	0.1226	0.3259	0.3503	0.2266

* P<.05, **P<.01, M = Mean, SD = Standar Deviation

Table 4.
Question and Some Teachers Answer about Application of 21st Century Skills in Learning Process

Question	Some Teachers' Answers
How is the application of critical thinking in the learning process	*I have a problem or have difficulty in evaluating and analyzing information* *I am able to develop multiple types of critical thinking* *I routinely apply two components of critical thinking (critical thinking)* *I consistently demonstrate multiple skills when conducting evaluation, analysis and synthesis in the learning process*
How is the application of problem solving in the learning process?	*I try to develop and follow the steps of problem solving (problem solving) and try to develop solutions* *I was able to solve some of the problems, but needed help to find solutions to those problems* *In general, I am able to provide solutions to problems in learning* *I apply problem solving skills (problem solving skills) in various learning situations*
How is the using information communication technology	*I have difficulty selecting information and using information and communication technology (ICT)* *I am still developing skills to access information and use communication and information technology (ICT)* *I understand and use media and communication and information technology (ICT) to design or create quality learning products* *I very often use, access information and apply technology skills using various communication and information technology media (ICT)*

Discussion and Conclusion

The results of studies on differences in teacher perceptions when actual teaching with preferred teaching about thinking and acting factors in 21st century learning indicate that critical thinking and problem-solving competencies become important competencies for students. This study shows that teachers have problems in the learning process. In this study, TechLit was also a competency factor highly emphasized in learning mathematics and science. The results of the studies on differences in IU-MSTs perceptions based on teaching subject (TS) on thinking and acting factors in 21st-century learning (TA21stCL) showed that IU-MSTs consider techLit as the most important competency to be mastered by students, but techLit was also the most difficult factor to be taught to students in the learning process. Thus, the special methods of teaching are needed to use in 21st century learning in Islamic University.

The findings of this study are in line with the research conducted by Afandi et al. (2019), which stated that there are four competencies in The Indonesian Parnertships 21st Century Skills (IP-21CS) for prospective science teachers, namely (1) 4Cs consisting of critical thinking, creative thinking, collaboration and communication, (2) ICTs consisting of technology, media and information literacy, (3) spiritual values comprising of religious beliefs and spiritual awareness, and (4) character building which consists of teachers' and scientific attitudes.

In this study, there was also a possibility that problem solving competencies are rarely taught by IU-MSTs. Even though, problem solving skills need to be mastered by students. Because the problem-solving is an important competency to be taught to students. In the learning process, problem-solving and creativity skill involves the describing problems with in-depth and clarity, analyzing problems with an open mind, evaluating alternatives, and considering various perspectives, gathering information for making decisions and developing plans, implementing and monitoring with integrity and evaluating the results with willingness to review the problem (Greenstein, 2012).

Integrated learning is learning that explores student knowledge broadly by combining various subjects of knowledge with environmental aspects, for example culture, communication, science, mathematics, social science, music and art (Drake & Reid, 2018). Integrated learning is characterized by the unification and use of several materials, strategies, methods, approaches and other aspects of learning (Haviz, 2016). The results of this study also show that the application of integrative learning in the Islamic University curriculum is going well. This opinion is supported from data from study results. Study data shows that lecturers expect their application to be good and also applied to the learning process. These results can be seen from quantitative data and answers to questions raised during interviews. Nevertheless, there are still lecturers who provide answers that have not been able to teach critical thinking, problem solving and use ICT in the learning process.

In this study, the results of the validity and reliability of the TA21stCL valid and reliable. According to Taber (2017), the results of this study show that the use of Cronbach's Alpha is relevant for reliable testing instruments used to collect. The results of other studies show that surveys on students' perceptions of critical thinking, creative thinking and authentic problem solving were dominant predictors in 21st-century learning practice (Chai et al. 2015; Jia et al. 2016; Ercikan & Oliveri, 2016).

The result of this study showed that Islamic university mathematics and science teachers (IU-MSTs) stated that problem-solving (PS), creativity (Creat), and technology literacy (TechLit) skills as 21st century skill were important

competencies to be mastered at Islamic university. In other words, the most important competencies to be mastered by students in Islamic University, on thinking skills was problem-solving (PS) and creativity (Creat), and on acting was technology literacy (TechLit).

Recommendations

This study recommends the use variaty of learning methods in 21st century learning to equip students with problem-solving (PS) and creativity (Creat) and Technological literacy (TechLit) skills. The further research needs to be studied specifically to examine 21st century skills in Islamic university separately, such as investigated critical thinking skills integrated with ICT or research on investigating problem solving skills with ICT.

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