Chemistry Teachers' Perceptions on STEM (Science, Technology, Engineering, and Mathematics) Education

[1]Farah Fathiaty Mardiyah, Nanda Saridewi[2]*, Evi Sapinatul Bahriah[3]

[1,2,3]Department of Chemistry Education, Faculty of Tarbiya and Teaching Sciences,
Universitas Islam Negeri Syarif Hidayatullah, Jakarta, Indonesia

Corresponding Author: *nanda.saridewi@uinjkt.ac.id

Abstract

Perception is a process of using the knowledge that a person has in interpreting an object. This study aims to determine the perceptions of Islamic senior high school chemistry teachers in South Tangerang, Indonesia towards STEM (Science, Technology, Engineering, and Mathematics) education. This study used descriptive qualitative method. The instrument used was an online questionnaire containing 17 questions with opened and closed forms, then the results were analyzed using hermeneutic techniques. Based on the results, it can be concluded that Islamic senior high school chemistry teachers in South Tangerang, Indonesia have a perception that STEM education is needed in learning.

Keywords: Perceptions, Chemistry Teacher, STEM Education.

INTRODUCTION

Information and communication technologies (ICT) are important for business and governance in 21st century (Ul-Amin, 2013). The use of ICT is becoming an integral part of education in many parts of the globe (Adeyemo, 2010).

One of the things needed by Indonesian education as a breakthrough and improvement in the 21st century is through the adaptation of educational methods applied in various developed countries, namely STEM. As in the USA, STEM is considered an important step to ensure the future success of a country (Widodo, Yuliati and Parno, 2018). The integrated STEM education is combination between combine science, technology, engineering and mathematics based on the relationship between subject and real-world problems (Stohlmann et al., 2012).

STEM is currently developing rapidly in several countries and has proven effective in improving the quality of education. As in the study of Acar, Tertemiz and Taşdemir (2018), that STEM affects the achievements of science and mathematics in Niğde, Turkey. Besides that, Rush (2011) stated that STEM can increase students' interest in the field of STEM.

Anggraini and Huzaifah (2017) argued that there have been several educational institutions that have applied STEM in the education system, although specific implementation guidelines regarding the STEM education in Indonesia are not yet available. Besides that, Permanasari (2016) argued that literacy of Indonesian students in the three types of literacy (science, mathematics and reading) still low so it needs changing, getting innovations and reforms in how to educate or train prospective teacher by constructing mastery of content, through the process of train skills based on good attitudes, character, and habits; by implementing STEM-based learning become one of the alternative learning potentials to construct skills in the 21st century. Science assessments using scientific literacy competencies can improve the quality of science education in Indonesia (Millah, Rubini and Pursitasari, 2021).

Teachers' perception of STEM also plays an important role in the success of its implementation goals. Fitrianasari and Budiyanto (2015) argued that perception will affect a person's perspective, understanding, responses, attitudes and behavior towards the perceived object, so perception is very important in life. Study about teachers' perceptions of STEM has also been

carried out in Saudi Arabia by El-Deghaidy and Mansour (2015), the results are known that teachers' perceptions of STEM education readiness in schools are still lacking, so it is directed to develop STEM-based Professional Development models. Perceptions are subjective so we need to check our perceptions with others and perceptions checking is an important communication skill because it helps people understand each other in their relationships (Wood, 2008). The chemistry teacher's perception of the STEM education is also certainly subjective, so there is a need to check for the smooth implementation of STEM education.

According to Hamalik (2005), the task of the teacher is generally to pass on knowledge and various skills to students so that the teacher must meet the ability measurements needed to carry out their duties. Thus, teachers' perceptions about STEM in chemistry learning material are more needed before integration of the STEM education to chemistry, moreover all Islamic Senior High School in South Tangerang, Indonesia based on the survey results, it had not to applying STEM education to chemistry learning.

Based on this background, this study seek to identify teachers' perceptions regarding STEM education.

The research questions focus on the following: What is the chemistry teachers' perception of Islamic senior high school in South Tangerang, Indonesia towards STEM (Science, Technology, Engineering, and Mathematics) education?

METHOD

This study is a descriptive; it is a study used to quantitative or qualitative data, and described a phenomenon, event or symptom (Sugiyono, 2011). Researchers choose to use descriptive qualitative.

Participants

The study population was all chemistry teachers in South Tangerang. The subject of this study was 10 chemistry teachers who taught at 9 state and private Islamic senior high school in South Tangerang, Indonesia.

Research instruments

The instrument used in this study was a questionnaire. The questionnaire used was closed and opened questions given online to respondents (Sugiyono, 2011). The indicators used in the preparation of this instrument follow the indicators used by El-Deghaidy and Mansour (2015) as shown in Table 1.

The data obtained consisted of two types, those are quantitative and qualitative data. Quantitative data were

obtained from the frequency of respondents 'answers to multiple choice while qualitative data were obtained from respondents' reasons for multiple choice answers.

Data collection and analysis

This study used hermeneutical data analysis. According to Mansour (2008), hermeneutic analysis is an interpretive approach, since it emphasizes the importance of the views of participants based on their experiences and their standpoint. This data analysis focuses on interpreting and understanding the meaning revealed in the text. The hermeneutic analysis process is (Diekelmann et al., 1989):

1. Reading each questionnaires' answer for each participant, to establish an overall understanding of the experience.
2. Identifying categories within each case "participant'.
3. Comparing categories and looking for similarities and differences. Interpretation is supported with textual references.
4. Identifying study themes that are limited to four indicators, supported by textual references.
   .

5. Analysing seek to identifiy pattern in the themes that occur across the texts and specifically examines relationships among identified themes. This is the highest level of interpretation.

6. Validating interpretation. The final step is skipped because limited to the fifth step.

Besides that, the percentage of respondents' answers from multiple choice was also calculated. In general, this study flow as stated in the diagram in Figure 1.

RESULTS AND DISCUSSION

All respondents have completed a questionnaire whose form was adapted from the study of Mansour (2008). While the questionnaire question indicator was developed into 17 questions with several answer choices and complemented by the reasons of each teacher, adapted from the study of El-Deghaidy and Mansour (2015). In general the results are summarized in Table 1.
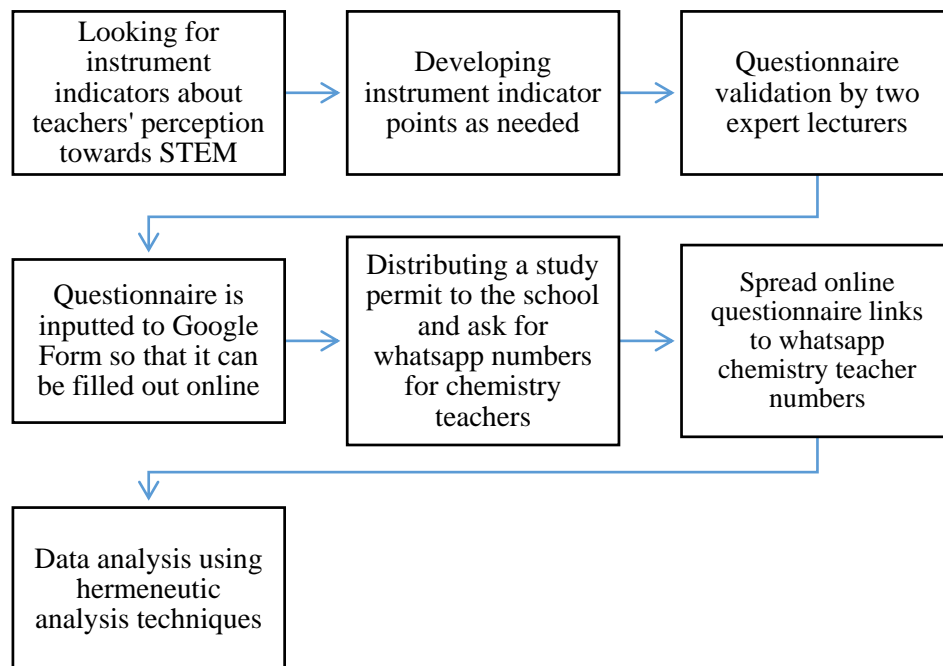
Procedure

Figure 1. Flow Chart

Table 1 Data on Teachers' Perception Results

Indicator	Subindicator	Findings
Teacher's views on STEM	STEM information source	The majority of respondents heard information about STEM from someone
	The STEM education trains students' HOTS	The STEM education can train students' HOTS (Higher Order Thinking Skills) because they connect learning with problems that occur in everyday life
	The STEM education fosters the skills needed in the 21st century	The 4C skills (communication, critical thinking, collaboration, and creativity) that students need in the 21st century can be grown through the STEM education because there are practices that can improve student skills

Teachers' views on STEM interdisciplinary learning	Urgency of the STEM education in learning	The STEM education is needed in learning because it can foster student skills
	Supporting factors apply the STEM education in learning	Supporting factors when applying STEM education in learning are students' attractiveness towards learning and the ability and readiness of teachers, because teachers are the main actors in learning
	The inhibiting factor applies the STEM education in learning	The inhibiting factor when applying the STEM education in learning is the Islamic School facility, because STEM requires more practice, while learning time is limited; students' motivation and thinking abilities are also low
	Teacher motivation applies the STEM education in learning	Motivation when applying STEM education in learning is from oneself, because they want to try and add knowledge
	Confidence in applying STEM in learning	The majority of respondents have the confidence to apply STEM in learning because by confident in implementing STEM, students will understand it better
	The effect of teacher perceptions on the STEM education on its application in learning	The perception of STEM will affect the way respondents apply it in learning, because the perception of STEM they have can make the application of STEM good
	Application of STEM education in learning at Islamic Senior High School	Respondents' views on the application of STEM integrated learning in Islamic School will improve the quality of education, but there is no intensive training to understand STEM-based learning

	Chemistry teacher readiness in applying the STEM education	The majority of respondents are ready to apply the STEM education in class, depending on the chemical material to be taught because not all approaches can be used for all chemical materials , so it must be adapted to the material
Partnership-based STEM Professional Development Program	Urgency of discussion between the professionals of the fourth sector	The majority of respondents view that direct discussions conducted by science teachers, mathematics teachers, scientists, and engineers (regarding STEM applications and activities) are needed so that there is good collaboration and mutual support for each other
	Urgency of forming partnerships between STEM professional figures with Islamic School	The establishment of partnerships between STEM professional figures with Islamic School will facilitate teachers in designing STEM integrated chemistry learning models so that implementation is maximized
	Urgency of establishing partnerships between non-governmental professional STEM parties and Islamic School	The establishment of partnerships with non-governmental professional STEM parties is needed, because the government has not fully socialized it, and so Islamic School teachers can find out about the STEM education
STEM as part of Islamic School culture	Urgency makes STEM a part of Islamic School culture	Cultivating STEM in Islamic School is needed, because the application of STEM will run smoothly if done by civilizing it. Accustomed to civilizing it, it will feel more easily recognized

	The teacher's actions when there is the formation of the STEM community	The action that will be taken if there is the formation of a collaborative STEM community in the Islamic School that will support and only actively participate. Because respondents will get information and knowledge about the STEM education
	The role of stakeholders	Growing a STEM culture requires collaboration among Islamic School stakeholders because there is a need for support from each party and without it , the STEM culture will be hampered

Teacher's Views on STEM

1. STEM Information Sources

Based on the results, majority respondents (40%) heard information about STEM from someone. The low interest in reading Indonesian people is only at 10%. The study of UNESCO in Puspita and Irwansyah (2018) showed that the reading interest index in Indonesia is only around 0.001, which means that there is only one person who has an interest in reading among a thousand people in Indonesia.

Beside that, according to Puspita and Irwansyah (2018), listening and oral culture in Indonesia are also considered as one of the causes of the low interest and reading culture in Indonesia. The listening culture such as hearing from someone (40%) or attending training/seminars/workshops/talkshows/conferen-ces (30%). In addition, result of APJII survey (Association of Indonesian Internet Service Providers) (2017), internet users in Indonesia who accessed social media were 87.13%. However, the study showed that only 10% of respondents get information about STEM from social media.

2. The STEM Education Trains Students' HOTS

Based on the results, 100% respondents argued that STEM education trains students' HOTS. This findings was in line with Basham and Marino (2013), stated that to be successful during STEM learning experiences, students need to be able to move beyond low level coginitive tasks (e.g., recalling facts in isolation) and gain a foundational understanding of

the content, which enables High-Order Thinking Skill.

The majority respondents' reasons stated that STEM can train HOTS (Higher Order Thinking Skill) students because it connects learning with problems that occur in everyday life (40%). This study was in line with Wang et al. (2011),that problem solving plays an important role in integrating engineering into science and mathematics. Besides that, Evangelisto et al. (2021) also found that students needed learning media with a contextual-based STEM approach to help them understand material and have Higher Order Thinking Skill.

3. The STEM Education Fosters the Skills Needed in the 21st Century

Based on the results, 100% respondents stated that STEM education can grow the skills needed in the 21st century. El-Deghaidy and Mansour (2015) argued that STEM education can help in promoting 21st century skills. Sulaeman et al. (2021) also found that integrating STEM education in an elective science class is valuable for students to achieve essential skills for their future.

The majority respondents' reasons stated that the 4C skills (communication, critical thinking, collaboration and creativity) needed by students in the 21st

century could be grown through the STEM education because there were practices that could improve student skills (30%). This is in line with the study of Acar et al (2018) which states that when STEM training is implemented, disciplines should be brought together and integrated to enable students to see the relations between concepts and principles. Additionally, Farwati et al. (2021) showed that teachers implement STEM to improve entrepreneurship skills, learning motivation, and various 21st-century skills. Onsee and Nuangchalerm (2019) also found that STEM learning helps students to gain more critical thinking, especially in the expanding knowledge period that students learn to connect prior knowledge and new experiences.

Teacher's Views on STEM Interdisciplinary Learning
1. Urgency of the STEM Education in Learning

Based on the results, 100% respondents argued that STEM is needed in learning. El-Deghaidy and Mansour (2015) stated that teaching STEM and linking the school science to real life situations can inspire students to take future careers in STEM. Parmin et al. (2020) also found that most of Indonesian science teachers believe that integrated STEM approach is important for teaching science in schools, believe

that they have enough knowledge on integrated STEM approach and believe that they worthy implement the integrated STEM approach.

The majority respondents' reasons (30%) stated that the STEM education was needed in learning because it could foster student skills. In addition, other respondents' reasons are STEM makes it easier for students to understand learning (20%), STEM makes learning more active (10%), STEM is a contemporary teaching method (10%), STEM is needed only depending on the material being taught (10%), STEM is needed so that there is no overlap (10%) and the remaining does not give reasons. However, Wang et al. (2011) showed that STEM integration is an innovative way of thinking about teaching STEM field that has the potential to impact education in a positive way. The effect of implementing STEM education is evident in the students' learning achievement, higher-order thinking skills, and motivation (Wahono, Lin and Chang, 2020).

2. Supporting Factors Apply the STEM Education in Learning

Based on the results, majority respondents had two opinions about supporting factors when applying the STEM education in learning. First, it was the attractiveness of students towards learning (30%). This finding was in line with of Basham and Marino (2013) that the attractiveness of students towards STEM learning can be increased if using challenge-based learning.

The second is the ability and readiness of teachers (30%). Stohlmann et al. (2012) stated that implementing effective STEM education requires dedicated, organized and knowledgeable individuals. The study of Basham and Marino (2013) are also in line, that teachers need a fundamental understanding of what STEM encompasses before they can develop curricular materials that meet students' need.

Respondent's reasons for selecting supporting factors in applying the STEM education in learning, stated that teacher is the main actor in learning (30%). This is in line with Uno (2010) that the teacher's role in learning is as a learning director who always tries to generate, maintain and improve students' motivation for learning.

3. The Inhibiting Factors Applies the STEM Education in Learning

Based on the results, 30% respondents stated that the inhibiting factor when applying the STEM education in learning was the Islamic School facility. Respondents was teachers who taught in a small private

Islamic School in South Tangerang, Indonesia taking into account the state of the Islamic School. This is in line with Minarti (2011), that facilities and infrastructure are very urgent in educational institutions, in order to support the success of educational organizations in achieving educational goals.

Respondent's reasons for selecting inhibiting factors in applying the STEM education in learning divided become three. The first reason is because STEM requires more practice (20%). But this is not found in the literature. The second reason was due to limited learning time (20%). This finding was in line with Ntemngwa and Oliver (2018) that another challenge that emerged from the teacher was lack of sufficient time for lesson preparation and instruction. Timms et al. (2018) stated about how to fit a modern and more inclusive version of STEM into an already crowded curriculum. Besides that, the study of Uno (2010) showed that an efficient education system was needed in managing time. Timms et al. (2018) also stated that if STEM is to be truly implemented, the designs will have to account for the limited space in the overall curriculum and assessment system will have to reflect the breadth of STEM. Landicho (2020) also found that

challenges in doing research include time and financial constraints as well as limited exposure and experience in doing research.

The third reason was low motivation, thinking ability and incomplete Islamic School facilities (20%). This findings was in line with Uno (2010) that teachers must be able to arouse the attention of students on the subject matter provided. Hakiim (2009) argued that in a change or renewal, the support of facilities and infrastructure is needed, so that the process runs smoothly. In addition, STEM learning necessarily requires teachers to integrate appropriate technology, pedagogy, and associated content knowledge in the classroom through design, because can illustrate the way of possible combinations of STEM knowledge as well as integration with school programs (Mishra and Koehler, 2006; Nuangchalerm et al., 2020).

4. Teacher Motivation in Applies the STEM Education in Learning

Based on the results, motivation of 60% respondents when applying the STEM education in learning was self. According to Hakiim (2009), increasing the ability to carry out professional duties as a teacher should emerge from within oneself,

although that encouragement can be stimulated from the outside.

Respondent's reasons about the source of their motivation in applying the STEM education in learning is divided become two. The first reason is because they want to try (20%). Bechtle (2014) stated that the greater our curiosity, the more things that can be used as a talk and that it is fertile ground. The second reason is want to add knowledge (20%). Stohlmann et al. (2012) argued that the teaching category is the largest since content knowledge is the most important for teachers new to integrated STEM education.

5. Confidence in Applying STEM in Learning

Based on the results, 80% respondents had the confidence to apply STEM in learning. Suharsaputra (2013) stated that in carrying out their roles and duties as an educational institution, capital requires confidence.

Respondents' reasons that make teachers confident in applying the STEM education in learning stated that students will understand it better (40%). Mirhan and Jusuf's study (2016) are in line, that benefits of self-confidence can increase positive energy in the body so that the skills possessed will appear optimally and be able to assist in completing a job properly.

While the other 20% of respondents have no confidence in implementing STEM. Based on the respondent's profile, the first teacher was still in college and other teachers felt they did not understand STEM because he was old. However, the study showed that teacher educators aged 61-70 had a higher awareness than those aged 20-30, because participants who had high STEM awareness had more work experience in the field of their study (Abdioğlu, Çevik and Koşar, 2021). As Margot and Kettler (2019) stated that age, gender and teachers' STEM experiences are the factors affecting their expectations from STEM education.

In this sense, it is recommended that class teacher receive both pre-service and in services training on how to use STEM activities (Acar et al., 2018). Qablan (2021) also stated that overcoming such limitations in teachers' abilities requires further training and field support to help them. The research result of Meester et al. (2021) can fuel teacher training programs and empower pre- and in-service teachers to create high-quality integrated STEM education.

6. The Effect of Teacher Perceptions on the STEM Education on its Application in Learning

Based on the results, 70% respondents argued that the perception of

STEM would affect the way respondents applied it in learning. This finding was in line with Wang et al. (2011) that teachers' perceptions of STEM integration strongly influenced how they designed their STEM integration unit. It is important that we focus on the teachers as they play a crucial role in the success of new reforms (Nugroho, Permanasari and Firman, 2019).

The majority respondent's reasons (30%) about the influence of teacher's perception of STEM education to its application in learning stated that the perception of STEM owned can make the application of STEM is good. Fitrianasari and Budiyanto (2015) stated that perception is a process of using the knowledge that a person has in interpreting an object and if the teacher's perception is positive then the teacher's performance is good so that the implementation of education runs well and viceversa. Sulaeman et al. (2020) also found that STEM education needs to be promoted especially in problem solving and designing activities to support positive perceptions. Kelley and Knowles (2016) suggest that the key to preparing STEM educators is to first begin by grounding their conceptual understanding of integrated STEM education.

In addition, 30% of respondents who does not agree that the perception of STEM will affect the way respondents apply it in learning because they do not understand it, have not tried it and cannot mention the reason. This is in line with Wood (2008) that perceptions are partial and subjective because each of us perceives from a unique perspective.

7. Application of STEM Education in Learning at Islamic Senior High School

Based on the results, 80% respondents argued that the implementation of STEM integrated learning in Islamic Senior High School would improve the quality of education. Hakiim (2009) stated that today there have been many developments and advances in the world of education aimed at improving quality of student learning outcomes. This findings was also in line with Stohlmann et al. (2012) that effective STEM education is vital for the future success of students.

The majority respondents' reason (20%) about the application of STEM education in learning in Islamic Senior High School stated that the absence of intensive training to understand the STEM-based learning. However, Anggraini and Huzaifah (2017) showed that in Indonesia there are already several educational institutions that apply the

STEM education in the education system even though the implementation guidelines are not yet available. Farwati et al. (2021) also found that in Indonesia, STEM education has been implemented in the learning process since 2014 and the number of researches on the implementation of STEM education are increasing from year to year. The Ministry of Education and Culture (2018) has held workshops on STEM several times, one of them is "Science, Technology, Engineering, Mathematics (STEM) and Industrial Revolution 4.0", which was held at the Ministry of Education and Culture office, Senayan, Jakarta, 12/12/2018. However, based on the results of the study, all respondents have never participated in it, apart from not getting the information, Islamic Senior High School management is under the Ministry of Religion, meanwhile, it has not conducted intensive training or workshops related to STEM for Islamic senior high school chemistry teachers.

Another reason for their view of the application of the STEM approach in learning at Islamic Senior High School is that in the 21st century students must be able to collaborate with the latest learning systems in Indonesia, one of which is the STEM education (10%); teachers are required to teach more creatively so that students can be more active (10%); students have the opportunity to connect knowledge and skills (10%); with the implementation of STEM, learning materials and time are effective (10%); serious and consistent implementation of STEM will improve the quality of education (10%); Islamic Senior High School learning requires complex knowledge (10%) and the rest does not provide reasons.

Meanwhile, the other 20% of respondents who were not ready to apply the STEM approach to learning in the sains class of Islamic Senior High School, based on the data from the profile analysis, the respondents were chemistry teachers who were still in college and had just started teaching at school. Considering the positive effects of STEM training and the problems that the teacher experience throughuht Acar et al. (2018), it is recommended that class teachers receive both pre-service and in-service training on how to use STEM activities. Evangelisto (2021) also recommend that teachers should receive professional development to help them understand. Pimthong and Williams (2018) also found that importance of promoting preservice teachers' understanding of the integrated nature of STEM and the connections among the disciplines.

Mardiyah, et al

8. Chemistry Teacher Readiness in Applying the STEM Education

Based on the results majority respondents (40%) had readiness to apply the STEM education in class but it depends on the chemical material they will teach because not all education can be used for all chemicals so it should be adapted to the material (40%). However, Anggraini and Huzaifah (2017) showed that many aspects that enable the implementation of STEM are included in the latest curriculum implemented in Indonesia today.

Other respondents' readiness in implementing STEM is when there is a local government policy (South Tangerang City) (20%) because it is a program that must be followed (20%). This is in line with Hakiim (2009) that there are various updates or changes in educational practices that come from above, which generally use administrative procedures. Qablan (2021) also stated that it should be reflected in the national science curricula to help teachers implement it in their classrooms. Aberilla et al. (2021) also found that need to develop a STEM based instructional design and this should be emphasized in the science curriculum.

Besides that, Uno (2010) also believes that in implementing the curriculum that has been set from the central, provincial and district/city, schools can also arrange life skills education programs that are appropriate to the circumstances and needs. However, Hakiim (2009) showed that the demand to improve professional abilities must arise from within oneself, without waiting for ideas or orders from above. For the successful implementation of integrated STEM education, teachers' competence could be a key element (Thuy, Bien and Quy, 2020).

Partnership Based STEM Professional Development Program
1. Urgency of Discussion Between the Professionals of the Fourth Sector

Based on the results, 90% respondents argued that direct discussions conducted by science teachers, mathematics teachers, scientists and engineers (regarding STEM applications and activities) are needed so that there is good collaboration and mutual support for each other. This findings is in line with El-Deghaidy and Mansour (2015) that a direct dialogue between science teachers, math teachers, scientists and engineers about STEM application and activities would be essential for promoting STEM education in schools. Sahertian (1981) stated that discussion is an exchange of opinions about a problem to be solved together because it is a way to develop the skills of its members in overcoming difficulties

by exchanging ideas. El Nagdi and Roehrig (2020) also found that the teachers developed strong conceptualizations of the STEM education, stressed the importance of collaboration, critical thinking, and motivation for teachers seeking to work in a STEM setting, and considered themselves moving towards established STEM teachers' identity.

Respondents also stated the reasons for their views on the urgency of direct discussion between professional figures of the four STEM fields. It was found that the majority of respondents (50%) had reasons for the urgency of direct discussions conducted by science teachers, mathematics teachers, scientists and engineers (regarding applications and activities STEM) so that there will be collaboration that will support one another. This findings was in line with Stohlmann et al. (2012) that different in licensures and backgrounds of teachers, it is important for schools to provide support and time for collaboration.

2. Urgency of Forming Partnerships Between STEM Professional Figures with Islamic School

Based on the results, respondents argued that forming partnerships between STEM professional figures with Islamic schools would facilitate teachers in designing the STEM integrated

chemistry learning model so that the implementation was maximized. This findings was in line with El-Deghaidy and Mansour (2015) that regard to the need for discussion among the figures of the four fields, they suggested that this dialogue can happen through a partnership between STEM parties, which teachers and engineers can work together to design models to explain scientific concepts. This findings was also in line with Wang et al. (2011), that teachers will begin doing STEM integration in the manner which is most comfortable to them and that this decision in highly correlated to their beliefs about the value and purpose of STEM integration; so that the implementation can maximal.

3. Urgency of Establishing Partnerships Between Non-Governmental Professional STEM Parties and Islamic School

Based on the results, respondents argued that forming partnerships with non-governmental professional STEM parties was needed because the government had not yet fully socialized it. This finding was in line with Stohlmann et al. (2012), that partnering with a local university or a nearby school can help teachers to feel that they have the support they need to be succeesful.

Respondents cited reasons for the urgency of forming partnerships between

STEM non-government professional parties with Islamic School and the majority of respondents argued that teachers could find out about the STEM education. This findings was in line with Wang et al. (2011) that the STEM professional development program confirmed and enhanced the teachers' thoughts about STEM integration, then it provided more opportunities and connections on how to use STEM integration to teach their subjects.

STEM as Part of Islamic School Culture

1. Urgency Makes STEM a Part of Islamic School Culture

Based on the results, respondents argued that the need to civilize STEM in Islamic School. This finding was in line with El-Deghaidy and Mansour (2015), that school culture plays a key role concerning the implementation of STEM at schools and STEM integration required a different school culture than that in non-STEM schools.

The majority of respondents' reason (50%) about the urgency to make STEM as part of Islamic School culture stated that it would be easier to recognize if become habitual then STEM implementation would run smoothly. Kholis, Zamroni, and Sumarno (2014) stated that school culture is philosophy, ideology, values,

assumptions, beliefs, hopes, attitudes, and norms that are shared and binding for the school community, which is basically essential and always related to various aspects of school life. Suharsaputra (2013) is also in line with this findings that habituation is a force that will form a strong character in all who interact, namely: teachers, students, colleagues and all members of school organizations.

2. The Teacher's Actions When There is Formation of the STEM Community

Based on the results, respondents' action if there was the forming STEM community, would support and only participate actively. According to KBBI online, participation is a matter of participating in an activity. In other words, teacher participation in organizations or activities can influence the success of a school (Priyastutiningrum, 2014) especially in the formation of STEM communities. Jiang et al. (2021) found that teacher educators can encourage STEM teachers to take action to contribute to the development of STEM education under the changing education climate.

The majority of respondents had reason for the action to be performed when there is formation of community

respondents STEM, because they will get information and knowledge about STEM education. This findings was in line with Wang et al. (2011), that the STEM professional development program confirmed and enhanced the teachers' thoughts about STEM integration. This findings was also in line with Priyastutiningrum (2014) that teachers are actively participating in certain activities will further increase the performance of the previous one and in accordance with the times.

3. The Role of Stakeholders

Based on the results, respondents argued that the role of stakeholders was needed because without collaboration among Islamic School stakeholders, STEM culture would be hampered. This findings was in line with El-Deghaidy and Mansour (2015), that the STEM school culture required collaboration among stakeholders and building a collaborative and supportive STEM community in schools. The intended stakeholders are categorized into two aspects, namely; internal aspects consisting of leaders, teaching staff, educational staff, students, school committees, and class communities; and external aspects consisting of networking with the local government and the development department, village institutions, sub-districts, the village

business world, and the socio-cultural dynamics of the local community, as well as the dynamics of developing technology (Kholis et al., 2014).

Respondents had reason about role of stakeholders in fostering STEM culture, that the need for stakeholder roles was due to the support of each other. This findings was in line with the results of Kholis et al. (2014) that the role of stakeholders is understood as the involvement of all people, a synergistic and harmonious group between the school's academic community, in an effort to achieve quality school improvement, which is not only related to its output aspects but also aspects of the processes undertaken and/or developed by schools. Qablan (2021) also stated that teacher need more support, collaboration, modeling, experience, and mentoring to continuously enhance teachers' skills in implementing STEM approach in their teaching.

CONCLUSION

The Islamic senior high school chemistry teacher's perception on STEM Education which the majority of sources of information only hear from someone, stated that STEM can train HOTS (Higher Order Thinking Skill) students because it connects learning with stakeholders. Besides that, STEM can

also foster students' 4C (communication, critical thinking, collaboration, and creativity) skills needed in the 21st century because there are practices that can improve student skills.

According to all respondents, STEM interdisciplinary learning is needed because it can foster student skills. Factors that support this are the attractiveness of students towards learning and the ability and readiness of teachers because teachers are the main actors in learning. Besides that, the inhibiting factor is the Islamic School facility, because STEM requires more practice, while learning time is limited, motivation and thinking ability of students are also low. On the other hand, the source of motivation for teachers to apply the STEM education in learning is from themselves because they want to try and add knowledge. The teacher also has the confidence to apply it because it will make students understand it better. The perception on STEM will also affect the way respondents apply it in learning because the perception of STEM they have can make the application of STEM good. The majority of respondents were also ready to apply the STEM education in class, adapted to the chemical material to be taught because not all approaches can be used. Respondents' views on the application of STEM integrated learning

in Islamic Senior High School will improve the quality of education but there is no intensive training to understand STEM-based learning.

The establishment of partnerships between STEM professional figures with Islamic School can be formed with the aim of making it easier for teachers to design STEM integrated chemistry learning models so that implementation is maximized. In addition, direct discussions also need to be carried out by science teachers, mathematics teachers, scientists, and engineers, so that there is good collaboration and mutual support for each other. The establishment of partnerships with non-governmental professional STEM parties is also needed because the government has not fully socialized it and so Islamic School teachers can find out about the STEM education.

Cultivating STEM in Islamic School is also needed because the application of STEM will run smoothly if it is done by cultivating it and it will feel easier to recognize. The teacher also supports and will actively participate if there is the formation of a collaborative STEM community in the Islamic School because the teacher will get information and knowledge about the STEM education. Not only teachers, fostering a STEM culture requires collaboration

among Islamic School stakeholders because without it, STEM culture will be hampered and the need for support from each side.

REFERENCES

Aberilla, OD, Salic, MH, Orbita, RR, Bagaloyos, JB , Demayo, CG, & Torres, MAG 2021, 'University students' acceptance of evolution: basis for STEM-based instructional design', *International Journal of STEM Education for Sustainability*, vol. 1, no. 1, pp. 33-44.

Abdioğlu, C, Çevik, M & Koşar, H 2021, 'Investigating STEM awareness of university teacher educators', *European Journal of STEM Education*, vol. 6, no. 1, pp. 1-18.

Acar, D, Tertemiz, N & Taşdemir, A 2018, 'The effects of STEM training on the academic achievement of 4th graders in science and mathematics and their views on STEM training teachers', *International Electronic Journal of Elementary Education (IEJEE)*, vol. 10, no. 4, pp. 505-513.

Adeyemo, SA 2010, 'The impact of Information and Communication Technology (ICT) on teaching and learning of physics', *International Journal of Educational Research and Technology*, vol. 1, no. 2, pp. 48-59.

Anggraini, FI & Huzaifah, S 2017, 'Implementasi STEM dalam pembelajaran IPA di Sekolah Menengah Pertama', *Prosiding Seminar Nasional Pendidikan IPA 2017: STEM untuk pembelajaran sains abad 21*, Universitas Sriwijaya, Palembang, pp. 722-731.

APJII 2017, Infografis Penetrasi dan Perilaku Pengguna Internet Indonesia. viewed 11 July 2019, <https://apjii.or.id/survei2017>.

Basham, JD & Marino, MT 2013, 'Understanding STEM education and supporting students through universal design for learning', *Teaching Exceptional Children*, vol. 45, no. 4, pp. 8-15.

Bechtle, M 2014, *Percaya Diri dalam Berkomunikasi*, Nafiri Gabriel. Jakarta.

Diekelmann, N, Allen, D, Tanner, C 1989, *The NLN Criteria for Appraisal of Baccalaureate Programs: a critical hermeneutic analysis*, National League for Nursing. New York.

El-Deghaidy, H & Mansour, N 2015, 'Science teachers' perceptions of STEM education: possibilities and challenges', *International Journal of Learning and Teaching*, vol. 1, no. 1, pp. 51-54.

El Nagdi, M & Roehrig, G 2020, 'Identity evolution of STEM teachers in Egyptian STEM schools in a time of transition: a case study', *International Journal of STEM Education*, vol 7. no. 41, pp. 1-16.

Evangelisto, C 2021, 'Critical thinking in STEM: a qualitative study of community college teaching techniques', *Journal of STEM Education*, vol. 22, no. 2, pp. 46-52.

Farwati, R, Metafisika, K, Sari, I, Sitinjak DS, Solikha, DF & Solfarina, S 2021, 'STEM education implementation in Indonesia: a scoping review', *International Journal of STEM Education for Sustainability*, vol. 1, no. 1, pp. 11-32.

Fitrianasari, H 2015, 'Persepsi Guru Terhadap Penyelenggaraan Pendidikan Inklusif Sesuai Latar Pendidikan di Kabupaten Blitar', SPD Thesis, Universitas Negeri Surabaya, Surabaya.

Hakiim, L 2009, *Perencanaan Pembelajaran*, CV Wacana Prima. Bandung.

Hamalik, O 2005, *Perencanaan Pengajaran berdasarkan Pendekatan Sistem,* Bumi Aksara. Jakarta.

Jiang, H, Wang, K, Wang, X, Lei, X & Huang, Z 2021, 'Understanding a STEM teacher's emotions and professional identities: a three-year longitudinal case study', *International Journal of STEM Education*, vol. 8, no. 51, pp. 1-22.

KBBI (Kamus Besar Bahasa Indonesia) online, viewed 10 January 2019, <https://www.kbbi.web.id/partisipa si>.

Kelley, TR and Knowles G 2016, 'A conceptual framework for integrated STEM education', *International Journal of STEM Education*, vol. 3, no. 11, pp. 1-11.

Kholis, N, Zamroni & Sumarno 2014, 'Mutu sekolah dan budaya partisipasi stakeholders: studi fenomenologi di sekolah konfesional MIN Tegalasri Wlingi Blitar', *Jurnal Pembangunan dan Pendidikan: Fondasi dan Aplikasi*, vol. 2, no. 2, pp. 130-142.

Landicho, CJB 2020, 'Research attitudes, motivations and challenges of STEM education researchers', . *International Journal of Technology in Education (IJTE)*, vol. 3, no. 1, pp. 49-61.

Mansour, N 2008, 'Religious beliefs a hidden variable in the classroom', *European Educational Research Journal*, vol. 7, no. 4, pp. 557-576.

Margot, KC & Kettler, T 2019, 'Teachers' perception of STEM integration and education: a systematic literature review',

International Journal of STEM Education, vol. 6, no. 2, pp. 1-16.

Meester, JD, Cock, MD, Langie, G & Dehaene W 2021, 'The Process of Designing Integrated STEM Learning Materials: Case Study towards an Evidence-based Model', European Journal of STEM Education, vol. 6, no. 1, pp. 1-23.

Millah, S, Rubini, B & Pursitasari, ID 2021, 'Analysis of the science assessment items using scientific literacy competencies', *Gagasan Pendidikan Indonesia*, vol.2, no.1, 2021, pp. 39-47.

Minarti, S 2011, *Manajemen Sekolah: Mengelola Lembaga Pendidikan Secara Mandiri*, Ar-Ruzz Media. Yogyakarta.

Mirhan & Jusuf, JBK 2016, 'Hubungan antara percaya diri dan kerja keras dalam olahraga dan keterampilan hidup', *Jurnal Olahraga Prestasi*, vol. 12, no. 1, pp. 86-96.

Mishra, P & Koehler, MJ 2006, 'Technological pedagogical content knowledge: a framework for teacher knowledge', *Teachers College Record*, vol. 108, no. 6, pp. 1017-1054.

Ntemngwa, C & Oliver, JS 2018, 'The implementation of integrated Science Technology, Engineering and Mathematics (STEM) instruction using robotics in the middle school science classroom', *International Journal of Education in Mathematic, Science and Technology (IJEMS)*, vol. 6, no.1, pp. 11-40.

Nuangchalerm, P, Prachagool, V, El Islami, RAZ & Abdurrahman 2020, 'Contribution of integrated learning through STEM education in ASEAN countries', *Jurnal*

Pendidikan Progresif, vol. 10, no.1, pp. 11-21.

Nugroho, Permanasari & Firman 2019, 'The movement of STEM education in Indonesia: science teacher's perspective', *Jurnal Pendidikan IPA Indonesia (JPPI)*, vol. 8, no. 3, pp. 417-425.

Onsee, P & Nuangchalerm, P 2019, 'Developing critical thinking of grade 10 students through inquiry-based STEM learning', *Jurnal Penelitian dan Pembelajaran IPA (JPPI)*, vol. 5, no. 2, pp. 132-141.

Parmin, Saregar, A, Deta, UA & El Islami, RAZ 2020, 'Indonesian Science Teachers' Views on Attitude, Knowledge, and Application of STEM', *Journal for the Education of Gifted Young Scientists*, vol. 8, no. 1, pp. 17-31.

Pathoni, H, Ashar, R, Maison & Huda, N 2021, 'Analysis student needs for the development of contextual-based STEM approach learning media in online learning: an evidence from Universities in Jambi, Indonesia', *International Journal of Research in STEM Education (IJRSE)*, vol. 3, no. 1, pp. 17-26.

Permanasari, A 2016, 'STEM education: inovasi dalam pembelajaran sains', *Seminar Nasional Pendidikan Sains 2016*: *Peningkatan kualitas pembelajaran sains dan kompetensi guru melalui penelitian & pengembangan dalam menghadapi tantangan abad-21,* Universitas Sebelas Maret, Surakarta, pp. 23-34.

Pimthong, P, Williams, J 2018, 'Preservice teachers' understanding of STEM education', *Kasetsart Journal of Social Sciences* , no. 41, pp. 289–295.

Priyastutiningrum, RW 2014, 'Pengaruh Kepemimpinan Kepala Sekolah dan Partisipasi Guru dalam MGMP Terhadap Kinerja Guru Bahasa Inggris di SMA se-Kabupaten Sleman', SPD skripsi, Universitas Negeri Yogyakarta, Yogyakarta.

Puspita, GA & Irwansyah 2018, 'Pergeseran budaya baca dan perkembangan industri penerbitan buku di Indonesia: studi kasus pembaca e-book melalui aplikasi iPusnas', *BIBLIOTIKA*: *Jurnal Kajian Perpustakaan dan Informasi*, vol. 02, no. 01, pp. 13-20.

Qablan, A 2021, 'Assessing teachers education and professional development needs to implement STEM after participating in an intensive summer professional development program', *Journal of STEM Education*, vol. 22, no. 1, pp. 75-80.

Rush, DL 2011, Integrated STEM education through Project-Based Learning, viewed 11 August 2018, <https://www.learning.com>.

Sahertian, PA 1981, *Prinsip dan Tehnik Supervisi Pendidikan*, Usaha Nasional. Surabaya.

Stohlmann, M, Moore, TJ & Roehrig, GH 2012, 'Considerations for teaching integrated STEM education', *Journal of Pre-College Engineering Education Research (J-PEER),* vol. 2, no. 1, pp. 28-34.

Sugiyono 2011, *Metode Penelitian Kombinasi (Mix Methods),* Alfabeta. Bandung.

Suharsaputra, U 2013, *Menjadi Guru Berkarakter*, PT Refika Aditama. Bandung.

Sulaeman, NF, Putra, PDA, Mineta, I, Hakamada, H, Takahashi, M, Ide, Y & Kumano, Y 2020, 'Engaging

STEM education for High School student in Japan: exploration of perception to engineer profession', *Jurnal Penelitian dan Pembelajaran IPA (JPPI)*, vol. 6, no. 2, pp. 194-210.

Sulaeman, NF, Putra, PDA, Mineta, I, Hakamada, H, Takahashi, M, Ide, Y & Kumano, Y 2021, 'Exploring student engagement in STEM education through the engineering design process', *Jurnal Penelitian dan Pembelajaran IPA (JPPI)*, vol. 7, no. 1, pp. 1-16.

The Ministry of Education and Culture 2018, Kemendikbud sambut revolusi industri 4.0 melalui praktik baik STEM dan HOTS, viewed 3 July 2019, <https://www.kemdikbud.go.id/main/blog/2018/12/kemendikbud-sambut-revolusi-industri-4.0-melalui-praktik-baik-stem-dan-hots>.

Thuy, NTT, Bien, NV & Quy, DX 2020, 'Fostering teachers' competence of the integrated STEM education', *Jurnal Penelitian dan Pembelajaran IPA (JPPI)*, vol. 6, no. 2, 2020, pp. 166-179.

Timms, M, Moyle, K, Weldon, P, Mitchell, P 2018, *Challenges in STEM learning in Australian Schools*, Australian Council for Educational Research. Camberwell.

Ul-Amin, SN 2013, *An Effective Use of ICT for Education and Learning by Drawing on Worldwide Knowledge, Research and Experience: ICT as a Change Agent for Education (a Literature Review)*, University of Kashmir. India.

Uno, HB 2010, *Profesi Kependidikan, Problema, Solusi, dan Reformasi Pendidikan di Indonesia*, PT. Bumi Aksara. Jakarta.

Wahono, B, Lin, PL & Chang, CY 2020, 'Evidence of STEM enactment effectiveness in Asian student learning outcomes', *International Journal of STEM Education*, vol. 7, no. 36, pp. 1-18.

Wang, HH, Moore, TJ, Roehrig, GH & Park, MS 2011, 'STEM integration: teacher perceptions and practice', *Journal of Pre-College Engineering Education Research (J-PEER)*, vol. 1, no. 2, pp. 1-13.

Widodo, L, Yuliati, L & Parno 2018, 'Scientific literacy materi fluida statis siswa SMA: studi kasus', *JRKPF UAD*, vol. 5, no. 1, pp. 30-33.

Winarni, J, Zubaidah S & H, SK 2016, 'STEM: apa, mengapa dan bagaimana, *Pros. Semnas Pendidikan IPA Pascasarjana UM 2016*, Universitas Negeri Malang, Malang, vol. 1, pp. 976-984.

Wood, JT 2008, *Communication in Our Lives (Fifth Edition)*, Wadsworth Cengage Learning. United States of America.