



ANALYSIS OF TEACHERS' RESOURCES FOR INTEGRATING THE SKILLS OF CREATIVITY AND INNOVATION, CRITICAL THINKING AND PROBLEM SOLVING, COLLABORATION, AND COMMUNICATION IN SCIENCE CLASSROOM

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ABSTRACT

The significance of learners acquiring the skills required in the 21st century, including communication skills, teamwork, ICT-related skills and socio-cultural knowledge, imagination, critical thinking, and problem-solving, has been extensively discussed. Integrating the 21st century into the curriculum requires teachers to have knowledge and resources to foster classroom practices. This qualitative study was designed to explore the resources that Indonesian science teachers use in supporting the implementation of the skills of creativity and innovation, critical thinking and problem solving, collaboration, and communication (4Cs) integrated science instruction. Data analyses include surveys, audio recordings of small and large group discussions, and group discussion artifacts of 28 Indonesia vocational high school science teachers to identify the type of resources that teachers have had access to support the integration of 4C into science instruction and the extent to which these resources promote the 4C integration into science instruction. The analysis indicates that teachers use multiple resources to help them prepare for 4C integration into teaching practices, including various professional development (PD) programs, various teacher collaborations, curriculum guidelines, and open resources. Teachers found that Teacher Professional Education (TPE) was the most favorable PD program, and curriculum guideline was the least effective for advancing 4C integration. Implications are discussed further.

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Keywords: 21st century skills; 4C integration; teacher resources; teaching preparation

INTRODUCTION

Over the past two decades, there has been considerable discussion about the importance of students acquiring skills needed in the 21st century (Bybee & Fuchs, 2006; Rotherham & Willingham, 2009; Trilling & Fadel, 2009; Bellanca, 2010; National Research Council [NRC], 2011). Students must be prepared with the knowledge and skills needed for the 21st century because current and future jobs require work with expert thinking or complex communication skills and interpersonal cooperative skill (Levy & Murnane, 2004). Like-

wise, it is essential to have 21st century skills, as students need to obtain academic content and understand how to continue learning and use what they have learned efficiently and innovatively in their lives (Dede, 2010). The literature describes several conceptual frameworks for 21st century skills, including the Partnership for 21st century Skills (P21), the EnGauge framework from Metiri/NCERL, the concept for 21st century skills from the Organization for Economic Cooperation and Development (OECD), the International Society for Technology in Education ICT Skills (ISTE), the European Reference Framework, and the National Educational Technology Standards (Dede, 2010; Voogt & Robin, 2012). Although

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these frameworks have various emphases, there is much agreement on what 21st century skills should be added to the curriculum. These include communication skills, collaboration, ICT-related skills and socio-cultural awareness, creativity, critical thinking, problem-solving, and the capacity to develop relevant and high-quality products (Dede, 2010; Voogt & Robin, 2012).

The implementation of 21st century skills into the curriculum, however, requires that teachers be prepared. Studies indicate that teachers are aware of the 21st century teaching and learning concepts (Clarke, 2014), and they think that the 21st-century skills are essential and that teachers prioritize the skills of creativity and innovation, critical thinking and problem solving, collaboration, and communication (4Cs) concerning other content (Haryani et al., 2019; Ningsih & Jha, 2021) and that their teaching practices for these skills differ (Van de Oudeweetering & Voogt, 2018). However, teachers do not necessarily feel prepared for implementation (Thijs et al., 2014), yet research suggests the importance of teacher preparation to effectively implement curriculum reform (Supovitz & Turner, 2000; Bantwini, 2010; Park & Sung, 2013; Lowe & Appleton, 2015 among others).

Over half a century, several studies have been conducted to examine and evaluate how educational reforms are put into practice and study factors that drive the effective implementation of curriculum reform. Implementation refers to the actual use of innovation or to what extent innovations consist of in practices (Fullan & Pomfret, 1977). Various studies indicate consistent teacher understanding and the way teachers perceived change regarding a new curriculum reform. Factors that were found to be influencing for an effective curriculum reform implementation including teacher professional development (PD), teacher collaboration, and teacher's belief that the reform is beneficial to students (Lam et al., 2013; Ryder & Banner, 2013; Fullan, 2015; Lowe & Appleton, 2015 among others). Effective curriculum reform implementation involves providing resources and structured guidance to ensure that the newly established curriculum and the suggested teaching techniques are provided in the actual classroom activities.

As many other countries have done, in 2017, the Indonesian Ministry of Education (MoEC) began promoting the curriculum integration of the 21st century learning skills and innovation known as the 4Cs: creativity and innovation, critical thinking and problem solving, collaboration, and communication. As previous-

ly reported by the World Bank Human Development Department for East Asia and the Pacific Regions, the lack of employability skills, productivity, and competitiveness has led to high youth unemployment in Indonesia (Di Gropello et al., 2011). The report shows that academic performance, working independently, communication, leadership, and creative thinking are the most demanding skills needed in Indonesia's current job market. The curriculum revision was thus established to address the need to develop a strong understanding of the competitiveness and productivity of individuals in the 21st century. Besides, MoEC has prioritized expanding and increasing investment in vocational education in response to rising youth unemployment and inadequate skills among workers (Di Gropello et al., 2011; Fitriansyah et al., 2020).

Thus, the implementation of the 4Cs into Indonesia science classrooms would also require that teachers be appropriately prepared. Following the adoption of the 2017 C13 revision, researchers took an interest in reviewing the literature on the suggested learning models to integrate the 21st century learning skills into practice (Murti, 2015; Redhana, 2019) how Indonesia teacher education addresses the curriculum revision (Haryani et al., 2019; Sari, 2019), and how pre-service science teachers perceived the revision. This research suggested that Indonesian pre-service teachers have a positive attitude toward 4C implementation and are aware that to become a teacher for the 21st century, they must learn how to implement 4C instruction (Afandi et al., 2018; Shidiq & Yamtinah, 2019). Also, there is a growing interest in examining whether the textbook being used underscored the integration of 4Cs (Yusliani et al., 2019; Hidayat et al., 2020). However, very few studies have investigated the preparedness of Indonesian in-service science teachers to implement the 2017 Indonesian curriculum revision focusing on 4C integration.

Many potential avenues for research arise, given the current state of the literature. We are particularly interested in teacher teaching resources, including teacher professional development programs, curriculum documents and guidance, teacher collaboration, and any information and materials designed to help teachers acquire knowledge and practices to integrate 4C into science classrooms. Our research sought to identify the resources that vocational high school science teachers access in support of 4C integrated science instruction. We were also interested in evaluating these resources, so our research asked: what resources do teachers access to support their in-

tegration of 4C into science instruction? More specifically, we were interested in: (1) What kinds of professional development do teachers access to implement 4C integrated science instruction?; (2) To what extent do teachers use curriculum guidelines to support their integration of the 4C into science instruction when developing their lesson plans?; (3) To what extent do teachers work with other science teachers (within school or teacher associations) to support their integration of the 4Cs into science instruction when developing science lesson plans?; (4) What other resources do teachers use to support their integration of the 4Cs into science instruction?.

Teacher preparation includes the provision of ample knowledge, purposeful curriculum programs, and adequate resources to support the implementation of the intended curriculum reform and to enable powerful learning (Darling-Hammond et al., 2020). This study could potentially provide valuable insights into the essence of the resources of the Indonesian vocational science teachers to prepare for the integration of the 4Cs into instruction.

METHODS

This qualitative study explored the resources that Indonesian teachers use in support of 4C integrated science instruction implementation. We collected data in surveys, audio recordings of small and large group discussions, and group discussion artifacts for data triangulation (Creswell, 2013; Yin, 2017). According to Payne and Payne (2004), group discussion is a way of gathering data from several people who share similar experiences and reflect on their shared meanings. Group discussion is an effective method for evaluating new ideas and exploring issues shared by targeted participants (Payne & Payne, 2004). The survey data in this study is used to support the analysis of group discussion.

This study involved vocational high school science teachers in one of the cities of West Kalimantan province, Indonesia considering the importance of preparing vocational high school graduates with skills for the workforce. The first step was to contact the local Department of Education, asking permission to collect data. After getting approval to collect data, we reached the leaders for the regional Vocational High School Principal Association and Science Teacher Associations to get an updated list of current vocational high school science teachers in the region. This region has ten vocational public schools

and 17 private schools. The Chemistry Vocational High School Science Teacher Association listed 20 chemistry teachers actively involved in the organization, while The Physics Vocational High School Science Teacher Association listed 17 active physics teachers. However, the Natural Science (*Ilmu Pengetahuan Alam, IPA*) Vocational High School Science Teacher Association has registered only seven natural science teachers in its database. Subsequently, an invitation for a group discussion was sent to all science teachers based on the above data.

A total of 28 science teachers from six public and eight private vocational high schools in the region agreed to participate in this study. Nineteen of the 20 chemistry teachers participated in the study; however, only five out of 17 physics teachers and four out of seven natural science teachers participated. Fewer natural science teachers participated in the study because, in some schools, the chemistry teachers also teach natural science and likely participated in the study as chemistry teachers. Moreover, there are fewer natural science teachers in the region because natural science is not taught in vocational schools. With the implementation of the new curriculum (C13), natural science is only being taught in vocational schools with business, management, and tourism, while chemistry and physics are taught in vocational schools of technology and engineering, health, and nautical majors.

The number of physics teachers available for this study was limited due to the timing of the study. The group discussions were conducted in the first week of February 2020. While the chemistry group discussion took place on a weekday (Wednesday), group discussions for physics and natural science teachers took place on Saturday based on the site availability and suggestions from the chair of Physics and Natural Science Teacher Associations. Their suggestions were to avoid interference with the teachers and schools preparing for the Grade 12 national exam. However, Saturday is a day off for teachers, and indeed some physics teachers confirmed that they could not participate on Saturday because of a conflict with other activities. Given the low numbers of physics and natural science teachers who participated in this study, we used aggregated data from small and large group discussion transcripts, group discussion artifacts, and survey data to analyze teachers' resources.

The participants' demographic profiles are presented in Table 1.

Table 1. Demographic Profile of Participants (n=28)

Demographic	n (%)
School type	
Public School	18 (64)
Private School	10 (36)
Teaching subject	
Chemistry	19 (68)
Physics	5 (18)
Natural science	4 (14)
Years of teaching	
1-5	7 (25)
6-10	8 (29)
11-19	7 (25)
20+	6 (21)
Gender	
Male	12 (43)
Female	16 (57)
Professional Teacher Certificate	
Yes	16 (57)
No	12 (43)

A group discussion, each on different dates, was convened for each of the three discipline areas: chemistry, physics, and natural science. The 19 chemistry teachers were broken into four groups. Since the physics and natural science teachers were much fewer, each session was held using a single group of those who attended. The total of 28 teachers was thus broken out into six groups.

On the day of each group discussion, teachers met in an arranged meeting room. The meeting started with a welcoming speech by each chairperson of the Science Teacher Association (chemistry, physics, and natural science), after which the primary researcher guided the meeting. The primary researcher formally introduced herself, welcomed the teachers, and thanked them for attending and agreeing to participate in the study. The primary researcher explained the objectives of the session, the directions, and the procedure for group discussion. The teachers were first given 15 to 20 minutes to complete the survey, with the primary researcher checking to see if there were questions regarding the survey questions. For the session with chemistry teachers, after completing the survey, teachers were asked to gather in self-selected small groups of four to six voluntarily.

Before the group discussions started, the primary researcher read the rules for discussion. Five questions were submitted to each group to guide the discussion. Each group was provided with notebooks, pens, markers, the primary researcher's name card for further contact information, and a large paper to write the discussion results. In their small group discussions, teachers were asked to share what resources they have had for learning the 4C and the extent to which those resources helped them plan the integration of the 4C into their science classroom instruction. The small group discussions were audio-recorded as data. During the small discussions, the primary researcher, who also acted as a moderator, checked each group to see whether the participants needed further assistance. Following the small group discussions, the moderator led a general discussion to discuss and summarize the group discussion results, which were also audio-recorded.

Four types of data were obtained: small group discussion audio recordings, large group discussion audio recordings, written responses from small and large group discussions, and survey responses. All group discussion data was transcribed and verified by participants through member checking to gain accuracy of the data (Creswell & Miler, 2000). All transcribed data was entered into a computer database. Survey data, written responses from each group and general group discussions, audio recordings from each group, and large group discussions were compiled for data analysis.

Data from group discussions was the main source for this study, supported by the survey data. The survey contained five questions about participant demographics, three multiple response questions, which allowed teachers to select more than one answer and to provide additional information on teachers' interactions during PD, and teacher collaboration activities and the degree to which these resources helped them integrate the 4Cs into their classrooms. Last, there was a five-point Likert item on teachers' level of 4C integration: highly integrated (5 Likert points), intermediately (3 Likert points), to not integrated 4C (1 Likert point). Survey data asked teachers to identify the external resources that teachers use to a large extent to help them build knowledge on and to implement the 4Cs, including the national curriculum guidelines, teacher professional development programs, teacher collaboration, and other resources if any. Survey data were gathered to identify the resources used by the teachers.

The transcribed discussion data were entered into NVivo 12 program, and the teachers' responses were listed and categorized based on the framing foci on resources the teachers have accessed to support 4C integration. For example, teachers mentioned participating in various professional development programs to implement the C13 revision and 21st-century skills. These types of teacher resources for teacher professional development programs were then categorized as Professional Development (PD). When teachers mentioned using various curriculum guidelines, they were coded as curriculum guidelines. Similarly, when teachers work with other science teachers or teachers of different subject areas, they were coded as teacher collaboration. Teachers' descriptions and comments regarding those resources were similarly coded. The purpose of the coding was to identify key ideas about the type of resources that the vocational high school science teachers use and how they support and foster the integration of 4C. The codes were

used to identify the text relevant to each of the research questions, and then the summaries are drawn from each subset of text used to construct all the research questions. These processes will lead to conclusions on the experience of vocational high school science teachers and the resources they have used to prepare for 4C integration (Yin, 2017).

RESULTS AND DISCUSSION

The novelty of this study is aimed at exploring the resources that vocational high school science teachers have access to in support of the 4C integrated science classroom. Data analysis indicated that some teachers use at least one resource. Many of them use more than one resource to learn how to incorporate the 4Cs into their science instruction, including the internet, teacher development programs, teacher collaboration, and curriculum guidelines (see Table 2).

Table 2. The Distribution of Resources Used by the Teachers

Teacher	Resources			
	PD	Curriculum Guidelines	Teacher collaboration	Internet
Chemistry	17	9	15	19
Physics	5	5	4	5
Natural Science	3	2	2	4
Total	25	16	21	28

1. What kinds of professional development do teachers access to implement 4C integrated science instruction?

A total of 25 out of 28 teachers had attended various professional development programs to support the implementation of 4C integrated science instruction. The professional development programs attended include Teacher Professional Training and Education (TPTE), Teacher Professional Education (TPE), In-House Training (IHT), vocational science teacher training, and single section educational workshops. Some of the teachers attended only one type of PD program, such as three who reported attending TPTE, three teachers attended TPE, two teachers attended a single section educational workshop, five teachers attended IHT, and two teachers attended vocational science teacher training. Another ten teachers reported attending more than one of the PD programs mentioned above. However, three newer teachers with one to three years of teaching experience indicated having no PD experience.

Teachers across science subjects referred to IHT as one of their resources. Most of the teachers reported that the current IHT programs focus on the ongoing implementation of the C13 revision, which includes strengthening students' character, literacy, the 4Cs, and higher-order thinking skills (HOTS). During IHT, teachers learned how to teach science with new learning standards based on C13 revision, were familiarized with the Competence Standards and Basic Competencies, were taught how to develop a curriculum-based lesson plan, learned what expectations they should have of students to develop higher-level thinking skills, and learned how to assess students' higher-order thinking skills.

Teachers articulated that *"In IHT, we practice to analyze and develop lesson plans that described how students can think critically, solve problems, and how students can function as a team and interact well."*

One of the teachers expressed the expectation to provide learning experiences that involves student comprehension and memorization of science content to make it easier for students

to interpret, synthesize, explain, evaluate, and eventually use the knowledge to generate a valuable product based on the science topic they have studied. IHT training helped with this, but a few teachers also reported useful training from workshops organized by their schools in collaboration with the local Educational Quality Assurance, the MoEC regional technical implementation unit.

The Vocational Competency Improvement Program was another PD program that teachers found useful for gaining knowledge regarding 21st-century learning skills. One of the physics teachers who participated in the Training for Physics Learning Competency Improvement Program expressed that the program helped him gain knowledge on teacher policy and teaching development to apply learning in the 21st century and how to use social media (the internet) as a source to find information on teaching materials that are aligned with learning. These experiences helped him to apply the suggested instructional strategies to his classrooms. He said,

“... We also practiced constructing lesson plans that are aligned with 21st-century learning and micro-teaching by applying 21st-century learning principles and designing HOTS questions.”

Teachers reported that participation in a PD program provided information on how to familiarize themselves with the curriculum guidelines and prepare to incorporate the 4Cs. Among the PD programs, most teachers reported attending IHT, but the most favorable PD was TPE. Teachers found that attending TPE was more beneficial than other PD programs because TPE not only provides learning theories, but the teachers also get to practice lesson plan development and conduct micro-teaching.

As one teacher described that *“In the TPE activities that I have participated in, we have been given the training to improve and to develop teaching tools that include: syllabi, lesson plan, and learning assessment that is integrated with 21st-century skills. We’ve learned how to make learning media that encourages students to think creatively and in an innovative way.”*

Another teacher articulated, *“... I learned how to develop a lesson plan that incorporates 21st-century learning skills. I also learned about guided discovery learning. This learning model encourages active dialogue in classroom activities, observations that allow students to ask questions, to think creatively, to think critically when asked to observe, and then from that observation, students are asked what to expect from the questions that arise. Each participant also has to practice micro-teaching.”*

In 2018, the Teacher Professional Education (TPE) program was specifically designed for

in-service teachers in the certification process, replacing the previous TPTE program. To obtain professional certification through TPE, a teacher must earn 24 credits: ten credits of teaching and learning material through hybrid learning, eight credits of the workshop and peer teaching, and six credits of school internship. Teachers who have obtained professional certification are granted a professional allowance. The TPE pedagogical materials include 21st-century learning skills (the 4Cs) and teacher professional development, teaching and learning theory, student cognitive development, curriculum and learning strategies, and learning assessment that emphasize students’ development of higher-order thinking skills.

However, admittance to TPE requires a preliminary qualification test and administrative qualifications, including that teachers have to at least been teaching in the current subject area since 31 December 2015. The problem for newer teachers is that they must not only pass the preliminary qualification test but must also meet the requirements of teaching experience. Although TPE was reported as the most valuable form of professional development in support of 4C integration, not all teachers have the same opportunity to participate in the program. Only science teachers who have been professionally certified after 2018 are most likely to benefit from knowledge and experience on integrating 4C into their science classrooms. In contrast, most senior teachers were certified after completing TPTE before the TPE program. Besides, 12 out of 28 teachers who participated in this study have not yet received a professional certificate, which means they have not previously attended the TPE program.

While many teachers found that professional development was helpful, this was not always the case. Some teachers were less enthusiastic about it. One teacher said,

“The IHT I attended was less focused and covered too many topics, discussed more on contextual learning, and students’ learning issues.”

He believes that to be effective, the IHT should focus on discussing one issue in depth.

Another teacher said, *“In most teacher training, the instructor only discusses teaching and learning in an ideal situation, while what we face every day in classrooms is mostly far from ideal in terms of students and learning facilities.”*

With the current educational mandates, most teachers feel that they still need the training to improve their ability to integrate the 4Cs. Specifically, PD programs that include learning concepts and allow teachers to practice designing lesson plans within their teaching context and

conducting micro-teaching so that all participants can also learn how other teachers teach science subjects using different learning strategies. Teacher professional development is one of the ways to prepare teachers to implement a new curriculum reform better. The findings of this study are aligned with previous research on curriculum reform, which shows the value of providing sufficient and continuous professional development for teachers to implement curriculum reform and to help teachers develop a better understanding of the reform and reform objectives and expectations (De Jong, 2000; Penuel et al., 2007; Thomas, 2008; Schleicher, 2016). The initial PD helps teachers and education stakeholders to familiarize themselves with, develop a thorough understanding of further, and to have adequate knowledge of the curriculum reform. Having considerable knowledge of the reform might raise teachers' confidence and awareness that change is essential.

Teachers found that participation in TPE and the Vocational Competence Improvement Program was beneficial because these PDs offer topics in 4C integration by offering learning theories, practicing the design of lesson plans, and conducting micro-teaching. While teachers mentioned the advantages of participating in TPE, not all teachers are eligible for this thorough training until they have passed the preliminary qualification test and met other requirements. Although a few teachers were concerned about the depth of the training, IHT is the PD program that teachers participate in the most because every school offers IHT as part of its annual school professional development programs for teachers and school administration. Given the requirements for participating in TPE and the improved access for all teachers to participate in IHT, IHT could be one of the best ways to support the implementation of 4C integration. However, IHT needs to be designed to provide in-depth learning and practice 4C integration through micro-teaching in the context of school background so that all participants can also observe and learn how other teachers use different learning methods to teach science subjects.

2. To what extent do teachers use curriculum guidelines to support their integration of the 4C into science instruction when developing their lesson plans?

The majority of the teachers reported using a combination of curriculum guidelines and other resources to support the 4C integration into science instructions. However, all newer science teachers who were not eligible for TPE have reported curriculum guidelines as their primary resource for 4C integration. Teachers do recognize

that they are expected to develop their instructions mirroring the national guidelines. However, teachers may adjust their lessons depending on school background and student characteristics.

The teachers reported that they use curriculum guidelines as a framework for the creation of teaching documents, including annual and semester learning plans, syllabi, and daily lesson plans. The curriculum guidelines help them organize their lesson plans to include learning objectives, selected teaching materials, learning models, learning strategies, and learning scenarios that integrate attitude, characters, and skills for the 21st century based on the Standard Competency, Core Competencies, and Basic Competencies.

In one group discussion, it was noted that *"For general chemistry, we use the Guidelines for Standard Competence, Core Competencies and Basic Competencies set out in the Curriculum Guidelines of the Department of Education for the preparation of lessons plans..."*

Another teacher expressed that they know *"Teachers need to incorporate the 4Cs in chemistry to promote the development of more critical thought and students' characters to interact well and to develop cooperative attitudes. The learning goals must be tailored to the academic performance metrics based on the Basic Competencies set out in the curriculum guidelines and adapted learning models that will be used, for example, to help students think creatively, communicate actively, and think critically."*

Moreover, data suggests that curriculum guidelines support teachers administratively, but other resources, such as teacher PD and teacher collaboration, offer greater opportunities for 4C integration into science instructions. Although the curriculum guidelines are considered to be the least helpful resource for preparing 4C integration into the science classroom, it is widely used by teachers regardless of their teaching experience. This result provides insight into the need to give exact terminology, rubrics, and directions on integrating 4Cs into science practices.

3. To what extent do teachers work with other science teachers (within school or teacher associations) to support their integration of the 4Cs into science instruction when developing science lesson plans?

Data analysis indicates that 21 out of 28 teacher participants in this study reported the benefits of teacher collaboration in their attempt to integrate the 4Cs into science instruction. Common teacher collaboration activities in the region included the Science Teacher Association based on the subject taught and a team teaching either with teachers who taught the same subject or with

teachers across the subjects. Teachers emphasized that collaboration work with their colleagues within the same school, especially learning from teachers in the same science subjects, fostered their 4C integration. The majority of chemistry and physics teachers in this study have the advantage of team teaching because some schools have more than two teachers teaching the same science subject. The teachers reported that, through team teaching, they could learn from teachers who have been invited to participate in current PD by sharing with their team. These teachers reported that they work together to develop syllabi, develop lesson plans, select learning materials, develop learning assessments, and solve learning problems based on an updated curriculum. Team teaching also helps them to carry out action research by exchanging roles as observers in their classrooms. Teachers also consider the importance of team teaching to shape their knowledge of 21st-century learning skills.

Not only do teachers work with their peers on the same subject, but there is also a need to work with other teachers across disciplines. As one of the chemistry group discussions noted,

"We collaborate with other teachers across fields/science because we need fundamental science and technology resources from other fields to effectively incorporate the 4Cs." All teachers agreed that knowledge of 21st-century learning helps them to select teaching strategies and conceptualize better their lesson plans to facilitate students' teamwork, develop analytical thinking, and promote effective communication. A well-planned and well-prepared lesson would increase the practice of intended skills in classroom activities.

For most participants in this study, teacher collaboration helped them learn about integrating the 4Cs because they can learn from other colleagues in their school who have recently attended teacher training. Teacher collaboration also provides useful resources for all teacher team members in the same school. The school teacher team works together to create syllabi and lesson plans, choose science subjects to be taught and explore learning methods and how best to use them to teach particular subjects to engage students and incorporate the 4Cs. This collaboration allows all the science teachers on the team to be at the same pace in preparing their teaching. Teacher networks and teacher collaboration supports and builds a convenient learning environment among teachers, which in turn motivates teachers to change their teaching style. These findings are consistent with previous studies, such as Ryder and Banner (2013), peer teachers and teacher's

role models strengthen curriculum reform implementation because peer teachers share relevant knowledge and ideas from their actual experiences. Despite teachers' agreement on the benefit of team teaching to effectively integrate the 4Cs, especially within the same science subject, the natural science teachers in this study did not consider team teaching as a learning resource. The natural science teachers in this study were taught in vocational schools with business and management majors and were the only science teachers in their home school, which might explain why they did not mention team teaching as a resource.

Some teachers also discussed the benefits of participating in teacher association. Similarly, Purwoko et al. (2017) documented the advantage of the teacher association (MGMP) and teacher training institute (LPTK) collaboration to enhance technical and pedagogical teacher skills. However, one of the senior chemistry teachers was concerned with the current inactivity of the Vocational High School Chemistry Teacher Association because of a lack of local government funding. She mentioned that she had attended some PD at the national level but found it difficult to share her experience with other chemistry teachers in the teacher association because they did not hold regular meetings like they used to. Considering the value of teacher collaboration, the Department of Education should provide continuous support for science teacher association activities. The school principals should also encourage science teachers' involvement in teacher association. Likewise, the boards of the science teacher associations should also update the data of their members to keep track of the participation of their members.

Most of the teachers in this study described the value of supporting a group of science teachers for continuing learning. This result echoes previous findings on the benefit of collegiate work to potentially enhance the teaching-learning mechanism of the new initiative program (Penuel et al., 2012).

Considering the benefit of teacher teamwork, another initiative that can be made is to maximize the efforts of team teaching and teacher association to improve professional teacher learning. As described above, two participating schools in this study have many chemistry and physics teachers in the same school. Teacher teamwork is better in both schools than in a school with only one to two teachers in the same subject. Given the advantages of teacher collaboration and the need to provide equal resources and information for all teachers to successfully

integrate 21st-century learning skills as mandated in the 2017 curriculum revision, the current administration of the Department of Education should support the activities of the vocational science teacher association. The Department of Education should also encourage all vocational science teachers to join and participate in their teacher association.

4. What other resources do teachers use to support their integration of the 4Cs into science instruction?

The data analysis shows that all teachers used the internet/websites as a learning resource to learn about 21st-century learning skills and 4C integrated science instruction. Increased availability of online resources makes it easy to find and locate information, such as finding examples of 4C integrated lesson plans, teaching and learning activities, and keeping up-to-date on current educational issues. The Indonesian Directorate-General for Vocational Secondary Education, along with the platform for the development of digital literate individuals, offers open-source learning to vocational high school students, teachers and parents. Teachers reported that they used this Indonesian Ministry of Education official website as a resource to get access to the updated curriculum document policy, eBooks, classroom activities, and classroom practices shared by other science teachers in the teacher forum portal.

Some teachers expressed that they use online resources for self-learning. Other teachers articulated that online group discussion provides resources for learning, where *“We shared information with fellow teachers in the same science subject using social media, such as the WhatsApp group.”* Another teacher also admitted that *“I am greatly helped by what was shared in the WhatsApp group. I used the teaching recording of other fellow teachers as a comparison and reference for my teaching.”*

The education policies, curriculum guidelines, supported curriculum guidelines, and learning materials, including eBooks, are now easier to access and download from the official website of the Indonesian Ministry of Education and Culture. Teachers reported that these resources could help them improve their lesson plans, develop more interesting strategies to engage students in learning, and align learning with the demands of 21st-century skills. Teachers believe that improving the teaching and learning process and incorporating the 4Cs into classroom activities provides both teachers and students with learning experiences that are relevant and appropriate to this changing time.

The digital shift that leads to the increasing use of online educational resources may positively respond to the need for equal access to high-quality curricula. These open educational resources allow teachers to adapt and improve their instruction to engage with the new curriculum (Tepe & Mooney, 2018). McGreal (2017) points out that the digital teaching and learning materials widely accessible online play a key role in supporting innovation in teaching and learning for sustainable education quality. Considering the trend of using open educational resources, teacher professional development programs in Indonesia should emphasize using reputable online resources to select the appropriate open educational resources for their classrooms.

Above all, teachers reported using more than one resource, including open educational resources, teacher PD programs, teacher collaboration, and curriculum guidelines. Having rich resources could potentially lead to better classroom practices. This study could therefore add to the literature the resources that Indonesian vocational science teachers have had access to prepare for the integration of the 4Cs and the obstacles that they have.

CONCLUSION

There are three key findings from this study. First, given the requirements for intensive teacher training, such as TPE, not all vocational high school science teachers have the same access to the training program for teachers until they are eligible to participate. The Indonesia MoEC, through the regional Department of Education, must provide more opportunities for all science teachers to have experiences with similar teacher PD programs. Besides, the local Department of Education should encourage all schools to organize in-house training focusing on 4C integration to ensure that all teachers have experienced an in-depth training and contextual practice of 4C integrated science instruction.

The second important outcome to be noted in this study is the crucial role of teacher collaboration as one of the resources for 4C integrated science instruction. Teachers have acknowledged the advantages of working together as a team and sharing up-to-date information on new education policies and teaching experiences. A commitment of support from school leaders and the Department of Education to promote teacher engagement through team teaching and teacher association must be sustained. The local Department

of Education must also continue to optimize the role of the vocational high school science teacher association in fostering the implementation of curriculum change. Another significant finding is the increased use of open educational resources among Indonesian vocational science teachers. This digital shift could potentially support and foster the dissemination and implementation of C13 revision. Due to the limited number of physics and natural science teachers who participated in this study, we recommend further studies should be recruited more participants from each science subject to properly identify the similarity and differences of resources available to gain a better understanding of how to effectively help all teachers to better prepare for 4C integration into science classrooms. After identifying teachers' resources addressing the curriculum revision, it would also be necessary to examine how teachers use their resources and integrate them into teaching practices.

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