

An Investigation of the Main Characteristics of Science Teachers In Elementary Schools Who Have Digital Pedagogical Skills

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ABSTRACT

The development of information and communication technology in learning has implications for 21st century teachers who are smart and skilled according to the needs of students in primary schools. This literature study aims to explain digital pedagogy as characteristics of 21st century teachers for teaching and learning in elementary schools. Articles reviewed in the form of journals were obtained from the Scencedirect, Sage, Scopus, and Proquest databases. This literature review study classifies the characteristics of 21st century teachers in primary schools based on the domain of planning, teaching material development, and teaching methods that are in accordance with the learning needs of the 21st century in primary schools. The 21st century teacher for learning in primary school is characterized by a role as facilitator for students to learn actively through managing technology as a medium and learning resource in the digital era. Recommendations for further researchers may explore the characteristics of 21st century primary school teachers in the assessment domain. In addition, in practical terms, the recommendations for this study are on developing teacher competence in elementary schools as a transformation towards digital pedagogy.

Keywords: 21st century teachers, 21st century learning, digital pedagogy, primary school

INTRODUCTION

The development of Information and Communication Technology (ICT) takes place quickly and massively to impact all areas of human life. The social life order of the community is transformed into a digital society (Bouzguenda et al., 2019; Heath, 2018; Mosco, 2017). This significant change has resulted in the emergence of characteristics of a digital society that is ideally skilled in accessing information quickly and testing the credibility of information (Nygren et al., 2019). Communication activities can be done easily, anytime and anywhere (Parsaorantua et al., 2017; Ratheeswari, 2018; Setiawan, 2018). Therefore, 21st century life skills such as critical thinking, creative thinking, being able to collaborate and communicate well (Bedir, 2019; Rotherham & Willingham, 2010; Van Laar et al., 2017). These skills are known as the needs of the global community that can be developed through 21st century learning.

The use of technology in learning activities is identical as 21st century learning. 21st century learning shifts the paradigm of teacher centered learning into student centered learning (Jabbarova, 2020; Mumianga et al., 2018). Teachers act as facilitators in learning, not providers of knowledge for students (Barrot, 2019; Evans et al., 2020; Jan, 2017; Özönder & Mirici 2021). Teachers are not the only learning resource for students to build knowledge and skills. The design of 21st century learning sees students as learning actors involved in learning experiences (Kariippanon, 2018; Miller & Bruce, 2017). Through the current role of technology and the internet it makes it easy for students to search and find information quickly and completely (Chen et al., 2018; Do Ba et al., 2017).

The 21st century learning curriculum in elementary schools touches on the design of active ICT-based effective and fun learning (Hanif, 2020; Tsai, 2020; Erstad & Voogt, 2018; O'Neal et al., 2017). Recent research related to curriculum design needs to support learners to acquire the skills needed in the 21st century through the involvement of teachers in integrating technology as the most relevant teaching material in the digital age (Anagun, 2018; Darling-Aduana & Heinrich, 2018; Malik, 2018; Mirici & Uzel, 2019). Related research has been developing an e-learning-based curriculum to respond that students are digital natives so that all students have the opportunity to become digitally capable individuals (Biskupic & Zorica, 2012; Gee, 2013). The digital age curriculum teaches students to find their digital solutions, not just technology users (Hipkins, 2017). Implications for the learning process relate to what and how a concept can be found with available resources, including the role of educators in teaching in their classrooms

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(Ab Kadir, 2017; Harari, 2018). Therefore, the success of this learning is inseparable from the teacher factor as the spearhead of implementing education.

Teacher competence in the 21st century is different from the previous era where digital pedagogy skills were indispensable (Clark, 2010; Robertson, 2019; Sailin et al., 2018). Digital pedagogy refers to the mastery of proper operation of digital media to be used and the process of mentoring students in learning. Innovations in teaching methods developed and carried out by teachers are the main characteristics of mastery of digital pedagogy (Mynbayeva et al., 2018). Digital technology capabilities are believed to have great potential to benefit student learning, generating opportunities for teachers to enhance the effects of learning (Barber et al., 2015; Jesson et al., 2018; Marek & Wu, 2020). The use of ICT in learning strengthens the interaction between students and teachers, students with students, and students with teaching materials. The accuracy and motivation of teachers involved in digital pedagogy is a major factor in improving the quality of learning.

Technology utilization offers a variety of possible solutions to improve teaching and learning inputs, processes, and outcomes that benefit students and teachers (Hussain, 2018; Pardede, 2020). The integration of technology in 21st century learning activities in primary schools should be designed with the principle of relevance to the development of primary school age students. Digital media and teaching materials are available in a variety of types and constructs very close to the student environment. Teachers as facilitators play a role in drawing up learning plans focusing on 21st century life skills, developing teaching materials and learning media, selecting effective teaching methods, to develop and implement objective and authentic assessments indispensable for the continuity of 21st century learning. In summary, 21st century teachers are reliable planners, implementers, and evaluators for effective learning. Until in turn, students as learning actors are able to construct knowledge and improve skills independently.

The issues discussed indicate that 21st century learning in primary schools requires the role of teachers to suit the needs of primary school students. This article discusses the characteristics of 21st century teachers in primary school learning. The novelty of this article lies in the study of the characteristics of 21st century teachers who focus on elementary school level. Therefore, the research question of the study has been formulated as "What are the main characteristics of science teachers in elementary schools who have digital pedagogical skills?"

METHOD

Research design

This article was compiled using literature study methods. Literature review studies are conducted to find new

frameworks or perspectives on topics through the synthesis of representative literature on an integrated topic (Torraco, 2005), in this study is characteristic of 21st century teachers in elementary school. There have been many articles about the characteristics of 21st century teachers, but the focus of the study of the characteristics of 21st century teachers at the elementary school level becomes the potential of this study to produce the new knowledge needed. The current condition is very suitable where pedagogy has developed into a digital pedagogy that leads to mastery of technology operations and the way of teaching. Literature studies are conducted by synthesizing articles sourced from international journals that refer to literatures on the characteristics of 21st century teachers in elementary schools.

Data collection and analysis

The data were collected via articles obtained via criterion sampling method from the Scencedirect, Sage, Scopus, and Proquest databases. Article selection is done using such keywords as 21 century primary teacher; primary teacher in digital age; primary teacher digital pedagogy; 21st century teaching in primary school. The criteria for the article analyzed are articles published from January 2016 to January 2021. Total of 207 articles were found that matched the search criteria. Screening is done in the abstract to find out the relevance of the article to the topic to be discussed and as many as 156 articles are excluded because it is irrelevant to the topic characteristic of 21st century teachers. Total of 51 articles were screened and only 22 articles were found in accordance with the study of the characteristics of 21st century teachers in elementary schools, so that a total of 22 articles were analyzed with relevance to the topic characteristic of 21st century teachers in elementary school on the study of learning planning, teaching materials, teaching methods and evaluation of learning. The search flow and article selection are presented in figure 1.

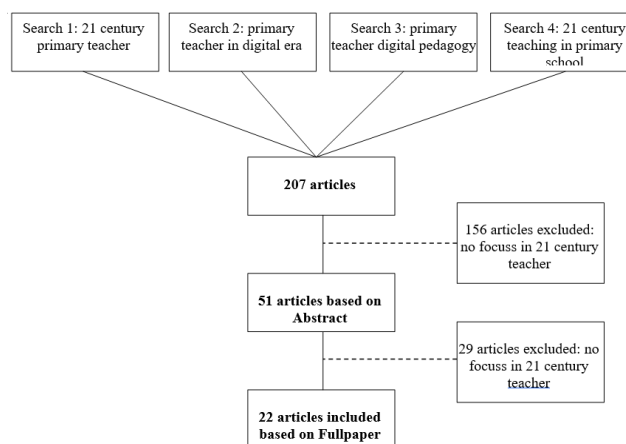


Fig. 1: Articles Selection Process

There are 22 articles that correspond to the study of the characteristics of 21st century primary school teachers. Details of the articles analyzed in this study are presented in Table 1. Table 1 presents the author’s information, database, and number of articles.

The study design in the articles analyzed consisted of literature study articles review, case studies, correlations, comparative studies and best practice relevant to the implementation of 21st century learning. Framework for guiding literature reviews from Templier & Pare (2015) applied, consists of formulating the problem, searching the literature, screening for inclusion; assessing quality; extracting data; analyzing and synthesizing data from the findings in selected articles for reference. The analyzed and classified articles focused on the characteristics of 21st century primary school teachers who were studied on the domain of learning planning, learning materials, and teaching methods. The novelty of this literature review classifies the characteristics of 21st century teachers in primary schools based on the domain of planning, development of teaching materials, and teaching methods that fit the needs of 21st century learning in elementary schools.

FINDINGS

The findings of literature studies in 22 articles that fit the topic in this article include how teachers in the 21st century in elementary to secondary schools. The results of this literature study focus on identifying the characteristics of 21st century teachers in elementary schools from different countries. In contrast to the studies from the previous article, in this article the findings of teacher characteristics are classified into three things, above the characteristics of teachers in planning learning, characteristics of teachers in developing teaching materials, and characteristics of teachers in the way of teaching.

DISCUSSION

Characteristics of 21st Century Teachers in Lesson Planning

Effective learning can be created by teachers as deep designers on the planning domain. Creating learning that suits the needs of 21st century students is challenging (Khalid et al., 2018). The study of the characteristics of 2nd century teachers in lesson planning in this article is focused on what

Table 1: Information About Articles Discussed in The Review

No	Database	Authors	Number
1	ScienceDirect	Santos & Castro, 2021; Zimmer et al., 2021; Abdulrahman et al., 2020; List et al., 2020; Seufert et al., 2020; Teo, 2019; Uerz et al., 2018; Zhang et al., 2017	8 articles
2	Scopus	Syawaludin et al., 2019; Tican & Deniz, 2019; Wasriep & Lajium, 2019; Ismail et al., 2018; Karakoyun & Kuzu, 2016; Khalid et al., 2018	6 articles
3	ProQuest	Adigüzel et al., 2017; Spiteri & Rundgren, 2017; Urbani et al., 2017	3 articles
4	Sage	Calderón, 2020; Calderón-Garrido et al, 2020; Talib, 2018; Lewis, 2017; Mantilla & Edwards, 2019	5 articles
Total			22 articles

Table 2. Information About Articles Discussed In The Review

No	Aspects	Indicator	Authors
1	Lesson Planning	21st Century Skill-oriented Learning Objectives	Zimmer et al., 2021; List et al., 2020; Tican & Deniz, 2019; Ismail et al., 2018; Uerz et al., 2018; Adigüzel et al., 2017; Talib, 2018; Lewis, 2017
		Curriculum Management Skills	Calderón-Garrido et al, 2020; Wasriep & Lajium, 2019; Lewis, 2017; Spiteri & Rundgren, 2017; Urbani et al., 2017; Karakoyun & Kuzu, 2016
2	Developing Teaching Materials	Relevant to the Life Needs of Students	Calderón-Garrido et al, 2020; Seufert et al., 2020; Teo, 2019; Adigüzel et al., 2017
		Developing Interactive Digital Teaching Materials	Abdulraham et al., 2020; Wasriep & Lajium, 2019; ; Syawaludin et al., 2019; Zhang et al., 2017; Abadi et al., 2017
3	How to Teach	Adequate in Understanding to Effectively Blend Technology into Their Teaching	Santos & Castro, 2021; Calderón, 2020; Mantilla & Edwards, 2019; Tican & Deniz, 2019; Wasriep & Lajium, 2019; Ismail et al., 2018; Khalid et al., 2018
		Effective Communication Skills and Collaborative Activities	Khalid et al., 2018; Le et al., 2018; Talib, 2018
		Teacher as Facilitator	Tican & Deniz, 2019; Khalid et al., 2017; Spiteri & Rundgren, 2017

competencies students will gain through a learning design. Thus, the lesson planning in this article can be defined as the characteristics of teachers in designing learning objectives and learning designs that are in accordance with the 21st century in elementary school. The following article review results find some characteristics of 21st century teachers in elementary school in planning the objectives and design of learning.

21st Century Skill-oriented Learning Objectives

The educational objectives of 21st century schools and the effect of those goals on schools themselves, individuals and social life are still being discussed (Adigüzel et al., 2017). 21st century learning is designed with the hope of meeting the real-life needs of students. Teachers' skills in learning planning should be able to formulate learning objectives that focus on creating effective twenty-first century learning that includes higher order thinking skills and critical thinking, collaboration, communication and creativity (Ismail et al., 2018; Talib, 2018). By implication, 21st century teachers must be skilled in sustainable development, effective communication, problem solving, and training students in their activities in the classroom (Tican & Deniz, 2019).

Higher order thinking skills (HOTS) involve cognitive levels including the ability to analyze, evaluate, and create (Anderson & Krathwohl, 2001). HOTS requires students to be able to apply new information or prior knowledge to answer problems in different situations. Other 21st century capabilities known as 4Cs include creativity, critical thinking, communication, and collaboration skills for today's students, challenged by the demands of the technology, informational, cognitive, and socio-emotional digital age (List et al., 2020). Providing students with mastery of these skills is useful to live real life and continue to the next level.

21st century teachers in primary schools understand how learning can be done to provide students with digital literacy. Digital literacy includes the ability to read, write actively, and communicate (speak, listen, and see) appropriately using digital resources to identify, access, manage, integrate, evaluate, analyze and synthesize various information (Zimmer et al., 2021). The technical dimension of digital literacy is the operational skills of students in using ICT for learning and in daily activities (List et al., 2020). Therefore, basic education needs to be educated using technology as a learning tool and to support students' technological literacy (Uerz et al., 2018).

Curriculum Management Skills

Education prepares students for real life as individuals who are able to use technology according to the needs of the 21st century so that technology must be integrated into the education curriculum in primary schools (Karakoyun & Kuzu, 2016). Teachers need to realize this as the potential

of digital technology in daily practice to improve student learning processes and outcomes (Spiteri & Rundgren, 2017). Digital learning organizations include the ability to access, apply, analyze and evaluate digital information and technology-based learning tools (Urbani et al., 2017). In summary, this competency consists of the use of digital technology instruments and didactic and methodological skills (Calderón-Garrido et al, 2020). Understanding of subject content, problems, and choosing a learning approach is tailored to the diverse interests and abilities of students. In the implementation aspect, teachers can use portfolios effectively as pedagogical tools through their inclusion in learning (Lewis, 2017).

The availability of information is abundant so that it needs to be followed by good curriculum management. In general, the curriculum applied in elementary schools currently requires the ability of teachers in technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) which together work together to help teachers to facilitate the learning process. However, the implementation of technology-based learning also experiences challenges with facilities, teaching readiness, and learners' readiness could interfere with the affordance and assistance (Wasriep & Lajium, 2019). Therefore, curriculum management is part of the characteristics of 21st century teachers so that learning is carried out precisely on the needs and conditions of students in their schools. Meanwhile, when in its application it finds problems, teachers who daily integrate digital technology find it easier to solve these technological problems through discussions with students (Spiteri & Rundgren, 2017).

Characteristics of 21st Century Teachers in Developing Teaching Materials

Understanding of subject content is mandatory for teachers to carry out teaching. The ability of teachers in the 21st century is not only using static teaching materials, but development in subjects continues. The study articles in this study classify them into two domains, consisting of content and development of interactive digital teaching materials.

Relevant to the Life Needs of Students

Elementary school students must be equipped with meaningful daily life information. Digital technology is undoubtedly needed to guide children's engagement with information, navigate ideas, and represent their thinking (Calderón-Garrido et al, 2020). Learning material is not only a transformation of information, but is more of an effort to advance people's thinking skills for their cognitive development (Adigüzel et al., 2017). Knowledge content in 21st century learning materials should be holistic which emphasizes life skills such as communication, creativity, understanding cross-cultural

collaboration and critical thinking (Teo, 2019). Teaching material development can also include the development of student personalities as a digital society (Seufert et al., 2020). Thus, students' needs can be met in facing the real life of the 21st century.

Developing Interactive Digital Teaching Materials

In the past, the presentation of teaching materials was mostly hardfile. Unlike in the past, the current condition of student teaching materials is equipped with a variety of teaching materials that are not only limited to text but in digital form. ICT involves gathering and sharing information in digital form. Multimedia technology is concerned with how information can be represented and presented digitally, using different media such as text, audio, video (Abdulrahman et al., 2020). The development of teaching materials for 21st century teachers in elementary schools can be done in the form of presentation such as multimedia technology which can be categorized as the use of ICT for learning.

Educational pedagogy continues to change to a variety of interactive learning tools in the teaching and learning process (Wasriep & Lajium, 2019). Digital teaching material technology has several interactive characteristics, meaning that it allows interactions to occur that allow people to digitally communicate information or ideas (Zhang et al., 2017; Karani & Mary, 2022). Strengthening interaction can be done by presenting questions or cases that require a response from users of teaching materials or students. The development of interactive teaching materials focuses on making learning devices that have student characteristics that can respond to teaching materials (Abadi et al., 2017). Relevant interactive technology used in elementary schools, for example augmented reality which can be accessed in real time so that the response of students to teaching materials can be done and assessed by teacher (Syawaludin et al., 2019). The interactive principle in 21st century teaching materials is more towards electronic-based teaching materials.

Characteristics of 21st Century Teachers in How to Teach

The creation of effective learning situations depends on the ability of teachers to know how their students think and learn. Good teachers are able to convey teaching, concepts and skills that are easily understood by students (Ismail et al., 2018). Primary school teachers must be able to enter the world of students, then bring students into a world with teachers in comfortable and pleasant learning situations. With this gives hope that learning is not a burden, but a need that can be obtained with the right method. The relation with learning methods in 21st century primary schools in this study refers to the skills of teachers in creating learning situations in ways that suit the needs, interests, and lives of students today.

Adequate in Understanding to Effectively Blend Technology into Their Teaching

21st century learning is synonymous with the involvement of technology in education. Therefore, ICT literacy is very important for 21st century teachers (Wasriep & Lajium, 2019). 21st century teachers in primary schools are capable in the knowledge and skills of integrating technology into the learning process. This readiness has been taken by prospective elementary school teachers while studying at university, some of which have developed the Technological Pedagogical Content Knowledge (TPACK) (Khalid et al., 2018). This program is a requirement to complete the entire course program to increase their effectiveness in the real practice of teaching in schools. The findings of previous research indicate that pre-service teachers have good abilities implementing TPACK. Structured approaches should be designed to help teachers in public schools implement 21st century learning with technology integration (Santos & Castro, 2021). Therefore, teachers of educational programs are challenged to educate the new generation by becoming teachers of the future (Calderón, 2020).

The ability of teachers to integrate technology in teaching methods can be seen in the use of different technologies in an appropriate way (Pipattanasuk & Songsriwittaya, 2020; Tican & Deniz, 2019), as a tool to facilitate teaching. Qualified teachers if they are able to diversify learning methodologies and choose effective audio-visual tools for student learning (Ismail et al., 2018). Thus, digital technology is needed to guide children's engagement with information, navigate ideas, and represent their thoughts (Mantilla & Edwards, 2019).

Effective Communication Skills and Collaborative Activities

In addition to understanding and skills in technology, effective communication skills are needed to increase interactions between teachers and students. The 21st century learning era is facilitated by many mobile-based media that are familiar to the world of students, including in elementary schools. The use of social media can be used as an effective communication medium in learning (Talib, 2018). Effective communication can be created through focused and comfortable situations so that communicants can convey their ideas well and completely.

Performance in teaching using social media can also be combined with collaborative learning strategies (Le et al., 2018). Teaching ICT skills alone is not sufficient to prepare prospective teachers who integrate ICT into teaching, but in collaborative implementation (Khalid et al., 2018). Teaching and learning sessions should be more activity-oriented, investigative and project-based, done collaboratively so that 21st century skills can be provided to students in primary schools.

Teacher as Facilitator

The role of the teacher in the context of 21st century learning is mostly the facilitator. Previously, there has been a paradigm shift in the learning approach from teacher centered learning to student centered learning. Consequently, students are active seekers and teachers are not the only source of learning. Teachers use digital resources to improve learning (Spiteri & Rundgren, 2017). The teacher acts as a facilitator who trains 21st century students to be able to apply 21st century skills through student activities in the classroom (Tican & Deniz, 2019). The teacher plays a role in teaching that teaches students how to learn through the use of technology to strengthen learning and nurture student creativity. Learning is not a transfer of knowledge. The skills of 21st century teachers are also skilled not only in technology but also in pedagogy and content (Khalid et al., 2017).

The findings in this review article generally find that the characteristics of 21st century teachers in primary schools refer to what teachers can do and are needed as professional teachers in 21st century teaching in primary schools. The characteristics of 21st century teachers in primary schools include the ability to plan lessons, develop teaching materials, and teaching methods.

CONCLUSION

21st century teachers in elementary schools need skills that fit the needs of students' lives in the digital age so that there are characteristics that are different from previous eras. The characteristics of 21st century teachers in primary schools have generally been discussed in three categories consisting of the domain of skills in learning planning, teaching materials, and teaching methods. This literature study concluded that the characteristics of 21st century teachers in elementary schools in the aspect of planning include the ability to determine the objectives of learning and the design of learning to be implemented. In the aspect of teaching materials development, teachers develop teaching materials containing content relevant to the needs of students' lives. In addition, the development of teaching materials is presented in an interactive digital form. Studies on teaching methods obtained understanding to effectively blend technology into their teaching; effective communication skills; active learning and teachers as facilitators.

RECOMMENDATION

Recommendation for researchers can further explore about the characteristics of 21st century teachers in elementary schools in the domain of assessment. In addition, in practical terms the recommendations of this study on developing teacher competence in elementary schools as a transformation towards digital pedagogical skills.

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