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A Proposed Problem-Centered Thinking Skill (PCTS) Model at Secondary Schools in Indonesia and Malaysia

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The purpose of this study is to discover the cost effective context and general components of the instructional system design model that might contribute positively to the Problem-Centered Thinking Skill (PCTS) Model for Science Lesson in Bandung, Indonesia and Selangor, Malaysia in Bandung. In total, there were 200 secondary school science teachers from those two locations participating in the study. The primary tool for gathering data was an open-ended Google form. Triangulation was used to increase the reliability of the data by conducting both participant observations and individual interviews. Researchers found that pupils did not acquire the material because of the teacher's inadequate explanations that did not follow a scientific learning process that applies critical thinking to higher order thinking skills. Furthermore, due to signal and quota restrictions during online learning, individuals were unable to study well at home. In order to help students in Bandung and Selangor enhance their higher-order reasoning skills, it needs a current model that is flexible and uses technology tools to integrate critical thinking and scientific reasoning. Problem-Centered Thinking Skill (PCTS) as a new way of thinking about science education is called for in this study, offering for a new model of scientific learning.

Keywords: HOTS, critical thinking, problem solving, problem-centered, thinking skill

INTRODUCTION

The pace of technological advancement is breathtaking, and the internet makes information instantly available to everybody (Halpern, 1992). The way we learn has to

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alter in order to adapt to the massive volumes of knowledge that are now at our fingertips. The emphasis of instruction should shift away from memory and practice and toward the process of scientific reasoning and communication, so that students do not have to be experts in every field of science (Ford, & Forman, 2006). The teacher's duty is no longer that of a 'transmitter' of knowledge, but rather a facilitator of knowledge production in order to help students acquire new skills. Higher-order thinking skills can not be taught using traditional models of teaching since they are prescriptive and conditional, and because knowledge is broken down into tasks (Driscoll, & Burner, 2005; Ragan, & Smith, 2004).

Instructional design models that focus the learner, the learning process, and learning environment are needed to promote higher order thinking skills, according to developments in cognitive psychology (Driscoll, & Burner, 2005). As a result of the pressing need to comprehend how people learn, educational psychology underwent a cognitive revolution. Models of the subject matter are developed throughout the learning process so that new information can be merged with previously acquired knowledge. Multiple representations of knowledge in the learning environment might help the learner to actively develop his own understanding and to critically think about the material. It is possible to use technology in this way because students use cognitive processes to understand the subject matter and because technology promotes interaction and collaboration, as well as personal reflection, among students of this type. To foster group work and problem solving, students might make use of social media sites like Facebook and Twitter.

When the Malaysian government announced the Multimedia Super Corridor (MSC) in 1996, one of its signature applications was the 'Smart School', which was designed to turn Malaysia into a knowledge-based society by utilizing ICT. Learning styles and numerous intelligences were considered, as were various instructional methods (Smart School Project Team, 1997). A process known as "pembestarian" or "making schools smart" was launched in 2006 to ensure that all schools will be "smart" by 2010 (Ministry of Education/MOE, 2008).

Schools in Indonesia have been ordered to remain closed in an effort to contain the spread of the Covid-19 starting from March 24th, 2020 to March 31st, 2022. More than 1.7 billion students around the world have been affected by the epidemic's school cancellations, according to data from 160 nations. More than 91% of the world's students were affected by the Covid-19. While the crisis has opened up new possibilities for technology, it has also increased the dangers associated with it. In contrast, it has supplied a plethora of information about the role technology plays in transforming the learning process, facilitating long-term training, and giving students throughout the world with a medium of instruction during distance learning (Abbasi et al., 2020).

Teachers in Malaysia were given student-centered instruction training as part of the country's cognitive revolution in order to develop students who would be part of the nation's knowledgeable and talented workforce. (MOE, 2006). Smart relationships with organizations that use project-based and web-based collaborative learning were also fostered by the MOE (Fong, Raja Maznah, Rozhan, Shekaran, & Chong, 2008; MOE, 2007; MOE, & Intel Malaysia, 2008; MOE, & Oracle Education Foundation, 2008). Since project-based learning and collaboration had a modest number of participants, it signified a shift towards online learning in schools that was more social and participatory. For example, a student's ability to learn and problem-solve improves when he or she is engaged in active learning. PISA 2009+ and TIMMS 1999 to 2014, two international exams, show that Malaysian students' performance has slipped below the international average. In other words, it appears that the efforts to establish student-centered instructional practices were not executed. Only 1-2 percent of Malaysian pupils are able to solve complicated math and science problems at the highest level, compared to 40 percent of Singaporean students, according to TIMMS 2011 and 2014. (MOE, 2013, p. 3-8). According to a study, Malaysian pupils fared less well than their counter parts in the United States in terms of knowledge retention, problem-solving abilities, and reasoning skills (TIMMS, 2011). Malaysian children are only 0.1 percent advanced in Reading, Math, and Science in PISA 2009+ compared to the international average of 8 percent of students (MOE, 2013, p. 3-10). Almost no Malaysian student can create multiple inferences, thorough comparisons and contrasts, critical assessments or hypotheses when they are studying for a test (MOE, 2013). Neither in mathematics nor in science could they demonstrate higher-order cognitive processes to understand or communicate results, or to suggest and support scientific ideas (MOE, 2013). That our educational system has an urgent need for instructional methodologies to facilitate higher-order cognitive processes and reasoning, is an indication of a significant problem.

To compare the math and science achievements of students ages 4 to 8 in different countries, a study called the Trend in International Mathematics and Science Study was also conducted (TIMSS). According to TIMSS, the educational system's performance in math and science can be measured by tracking student success. TIMSS was conducted every four years, particularly in 1995, 1999, 2003, 2007, 2011, and 2015.

TIMSS has examined Indonesia during the previous four years. Math achievement in Indonesia is still under worldwide examination, according to TIMSS. It was found that Indonesia ranks 35th out of 46 countries, on average, in the 2003 TIMSS study, whereas the global average is 467. TIMSS surveys conducted in 2007 and 2011 show Indonesia to be 36th out of 49 participating nations, with an average score of 397, and 38th out of 42 countries, with an average score of 386, whereas the global average score is 500. For example, Indonesia was in 44th place out of 49 countries in the most recent TIMSS 2015 results.

Table 1
Indonesia's TIMSS results

TIMSS RESULTS				
Year	Rank	Participants	Indonesian Average Score	International Average Score
2003	35	46 countries	411	467
2007	36	49 countries	397	500
2011	38	42 countries	386	500
2015	44	49 countries	397	500

There are four categories of survey participation: low, medium, high, and advanced based on the TIMSS criteria, which indicates that Indonesia's rank is on the lower end of the scale. Although the 2011 TIMSS ranked Indonesia at the bottom of the rankings, the country has been plagued by decades of conflict. For the year 2011, here are TIMSS achievement results:

Table 2
Indonesia's achievements in the 2011 TIMSS results

TIMSS RESULTS in 2011					TIMSS RESULTS in 2015*			
	Low	Middle	High	Advance	Low	Middle	High	Advance
Science	54%	19%	3%	0%	54%	15%	6%	0%
Math	43%	15%	2%	0%	54%	15%	6%	0%

Table 2 illustrates that Indonesian students' competence is on the lower end of the range, according to the 2011 TIMSS research (Hadi & Novaliyosi, 2019). TIMSS measures a person's knowledge and skills in two areas: mathematics and science (science). Data on student achievement in math and science is collected by TIMSS to improve teaching and learning by gathering information on various curriculum forms, teaching techniques, and school environments. Math and science proficiency is one of several goals pursued by TIMSS. If we look at and reflect on the results of the TIMSS survey, which is conducted every four years, we may utilize the data from it to evaluate learning and the government's response to improving education in Indonesia. The results of the TIMSS must be re-examined when TIMSS team members in Indonesian schools take samples of students. So this isn't the only instance in which Indonesian society or university students are mentioned or depicted. Even in the international arena, Indonesian students have a lot to be proud of, such as their victories in the mathematics and science Olympiads (Hadi & Novaliyosi, 2019).

Bybee and Trowbridge (2008) found that the pedagogical method of inquiry-based learning is being used to teach scientific thinking and generate hypotheses, conduct experiments, or observe and evaluate. It's important to note that these methods of reasoning are restricted to only three types of reasoning: inductive, deductive, and transitional. In addition, traditional models of critical thinking emphasize the appraisal of one's own knowledge and abilities (Anderson & Krathwohl, 2001; Dwyer, Hogan & Stewart, 2014). These models' flaws include a lack of consideration for higher-level thinking (Dwyer, Hogan & Stewart, 2014). Malaysian pupils' ability to acquire higher-order thinking skills has been hampered by the usage of these outdated instructional models (MOE, 2013).

Instructors in Indonesia have been advised to give their lessons and teaching methods for observation, as well as to observe the lessons of other teachers, in order to promote professional growth for the country's educators. As a result, educators are able to benefit from the expertise of their peers and incorporate that knowledge into their own classroom practices. There are a number of alternative tales, however, that argue that partnerships do not always result in such benefits for both parties, but rather strife (Clift et al., 1995; Johnston, 1997).

Continuing professional development programs are needed even in Indonesia, which is the focus of this investigation. As an alternative, the realities that instructors face while teaching can not usually be addressed in national in-service training programs. As part of their on going professional development, teachers in Malaysia are required to enrol in courses at organizations like PPPG, or the National Teacher Training Centres, and LPMP, or the Educational Quality Assurance Institutes (Japan International Cooperation Agency, 2003). The Pemantapan Kerja Guru (PKG) program was then developed into Musyawarah Guru Mata Pelajaran (MGMP: Subject-wise Teachers' Self-learning Association), which was later developed into Musyawarah Guru Mata Pelajaran (MGMP) (Adey and Dillon, 1994; p. 2; p. 3). MGMP events, on the other hand, tend to be hosted in districts' centers, drawing participants from all over the region, whereas clinical school activities, such as the original PKG activity, are rare due to a lack of funds. In Indonesia, in-service training has little impact due to these characteristics (Andrisyah, & Ismiatun, 2021).

While some informal school-university collaborations have been formed in Indonesia, they are rarely studied as a matter of different management level from basic to higher education (Darling-Hammond et al., 2017). In this context, there is paucity of research regarding school-university collaborations on teacher professional development, knowledge and insights into how classroom practices might be used to help teachers' professional development are limited (Greenhow et al., 2018).

As a result of their lack of resources, Indonesian educators face a huge challenge in honing their professional skills. Because university faculty members are meant to serve as intellectual resources for teacher development, they are unable to collect practical expertise and ideas from their colleagues (Krishnamoorthy & Keating, 2021).

New models and definitions for science reasoning and CT have evolved. A paradigm combining CT with scientific reasoning is missing, though (Oddone, 2019). Deductive reasoning can be developed in a variety of ways, including by resolving cognitive conflict, using the "Arc Transitive of Substitution" (A.T.S.) to apply rules of substitution using conditions and structures (Arslan, Göcmencelebi, & Tapan, 2009; Duval & Egret, 1989), and many other approaches. Scientific thinking is evolving at a rapid pace (Bueno, 2102; Bolduc, 2014). Thus, a modern model combining scientific reasoning with CT that is relevant to Malaysia's current circumstances is needed. As a mental habit, cultivating a culture of thinking is essential.

It is possible that other processes, such as teamwork, might be introduced via using technology for science education, such as games and discussion boards (Hong, Hwang, Liao, Lin, Pan, & Chen, 2014). The ability to cultivate critical thinking through the use of a variety of technological tools has also been demonstrated among teachers in Kuala Lumpur, Malaysia (Haghparast, Nasaruddin & Abdullah, 2014). It's also been proved that flipping the classroom is a promising method. It makes instructor-led group more effective. The use of it as a successful alternative method in the context of distance education practices is a possibility. (Yang, Chuang, Li, & Tseng, 2012). Using the internet and web-based, web-distributed, or web-capable technology tools for instructional purposes creates a novel educational notion known as critical thinking dispositions. It revolutionizes online education by transferring digital content and providing a learner-centric environment for instructors and students. With the introduction of new pedagogical strategies that are both successful and supportive of the development of information literacy and critical thinking abilities. Therefore, there is a need for current models that can be used with technology tools for critical thinking and scientific reasoning.

Based on the background of the study above, the research problems presented in this study cover in the following questions: 1) How is the context of Problem-Centered Thinking Skill (PCTS) Model for Science Lesson in Bandung, Indonesia and Selangor, Malaysia? 2) What are the general cost-effective components of the instructional system design model that can provide a positive contribution in Problem-Centered Thinking Skill (PCTS) Model for Science Lesson in Bandung, Indonesia and Selangor, Malaysia?

METHOD

Sample/ Population

100 science secondary school teachers from Bandung, Indonesia, and 100 science teachers from Selangor, Malaysia of 6^{th}- 9^{th} grade classes, participated in this study. The study population consisted of both male and female teachers. Both schools were selected for the study because of their similar characteristics in terms of open systems and their online instructional design models established for students in learning.

Data collection strategy/ procedures

Use of the instructional system design model in constructing the Problem-Centered Thinking Skill (PCTS) Model was studied utilizing an online focus group discussion, in-depth interview and document analysis from the related research as the tools for gathering the data. This research was approved by the regional committee for educational research ethics and the secondary schools' data protection officer. It was performed in accordance with the Helsinki Declaration. 200 All participants were given verbal and written information, and informed consent is gained from each. Participants in the study are male and female science teachers from secondary schools in Bandung, Indonesia and Selangor, Malaysia, and special care was taken to adhere to the proper norms of research ethics.

Before observations, all participants were informed that they might cease their involvement at any moment or ask the researcher to leave the room under certain circumstances. It was made certain that the observations did not interfere with the ongoing instructive process. Before interviews, participants' agreement was confirmed, and they were told of their right to end or suspend the interview at any time, as well as their right to decline to answer any questions that made them feel uncomfortable.

Instructional design models and methods were examined in Bandung and Selangor to gain a full understanding of the best practices for planning and developing a science lesson's PCTS Model. This research instrument employs a Likert scale with five answer categories for assessing the data (Strongly Agree, Agree, Doubt, Disagree, Strongly Disagree). Gathering data for this project was a collaborative effort amongst instructional designers, pedagogical specialists, and practitioners. The vignettes reflect the sense of support, informal mentoring, and social connection that characterises participatory culture through their openness, sincerity, and shared goals (Jenkins et al., 2016). 200 educators from Bandung, Indonesia and Selangor, Malaysia took part in the study. Throughout the investigation, pseudonyms were used to protect the anonymity of participants. This collective case study aimed to elucidate specifics of real-life experience, which the small sample made possible (Thomas, 2016).

Data Analysis

Using a descriptive qualitative technique, this study analyzed one or more examples or occurrences in great detail (Gall et al., 2013) mainly taken from the documentary and interview. The transcripts of the interviews are word for word. Transcriptions of the audio recordings that were taken during the observations were added to the researcher's field notes that were included in the observation guide. At first, an inductive, open method was used to analyse the interviews and observations, and then, after that, a more specific inquiry based on the theoretical framework was carried out. Both the content of the communication as well as the manner in which symptoms and concerns were communicated were given attention. The discovered codes and categories were explored both case by case and across instances in order to provide light on differences and similarities between the patient, family member, and physician groups as well as across the cases themselves. Its communication theory was utilized to assist in the process of condensing and organizing the text that was obtained from the participant observation notes and transcripts for each individual instance (Jespersen et al., 2017).

FINDINGS

Problem-Centered Thinking Skill (PCTS) Model for Science Lesson in Indonesian and Malaysian Context

The Reality in Science Education

Education in science is more than just imparting scientific knowledge; it's also about teaching students how to conduct scientific research. The acquisition of scientific information, therefore, requires the use of scientific procedures and rationality. In order to instruct students in the scientific method, the teacher must provide guidance and provide challenges at each level of the investigation process while also focusing on scientific inquiry. If this is the case, then students who study science and put their knowledge into practice will be well-equipped to reason about and argue scientific matters (MOE, 2013).

Scientific knowledge and ideals should be taught in an atmosphere where students may collaborate with other scientists, not merely be taught as facts. This will help students understand the impact that the scientific community has on their own personal and professional development (Hogan & Fisherkeller, 2005). A new set of skills is required of the teacher in light of the student population's wide range of social, cultural, and personal backgrounds. Teachers need to cultivate a mindset of critical thinking.

The Malaysian Context

Students in secondary schools in Malaysia still don't seem to grasp the underlying principles of science and instead appear to be content to memorize information. According to Chong (2005), many students in Form 6 are still struggling to grasp the fundamental concepts of science as they focus on memorizing information. As a result, many students had a hard time comprehending the language of science, and this resulted in many scientific misconceptions.

There was a disconnect between the way science was being taught and the methods used by the professors. Scientific knowledge was presented as facts and memory work was encouraged by science teachers (Tan, 2002). For whatever reason, professors were more interested in teaching science principles than letting students create their own hypotheses and conclusions by conducting experiments. Rather than letting students conduct their own experiments, teachers favored showing them how to do it.

Without a shift of critical thinking skills in the emphasis on obtaining scientific information, the National Science Education Philosophy's goals of cultivating a culture of science and technology and creating competitive persons (MOE, 2002) may not be reached at all. The use of collaborative learning and problem solving in science classes is one way to stimulate scientific enquiry. This is because the scientific methods of investigation and reasoning are learned when students work together to solve issues in science (Belland, Glazewski, & Richardson, 2008; Halpern, 1992).

The Indonesian Context

The Ministry of Education and Culture in Indonesia has complete responsibility over the organization and selection of all curriculum components in the country's education system. It has been the MOEC's traditional role to send new programs to local schools and teachers from the top down, a system known as "top-down" education. When it came to educational decentralisation efforts by government in 1994, the government pushed for schools to offer courses that were more in line with the needs of local socioeconomic groups and contexts (Bjork, 2004). Local education authorities, schools, and teachers gained more autonomy and responsibility in 1999 after the government strengthened its decentralization strategy (Heyward, Cannon, & Sarjono, 2011). It was part of this aim to highlight students' capacity to respond to global concerns and rapid breakthroughs in science and technology that a national competency-based curriculum (Kurikulum Berbasis Kompetensi [KBK]) was designed. An educational policy established nationally in 2004 called for teachers to adjust their lessons to the specific needs of their students.

As a result of efforts to improve teacher preparation and professional development, promote educational research, and build the national curriculum, positive changes in the education system are being felt in the teaching and learning of scientific concepts (Lefstein et al., 2020). To better understand Indonesia's current education system, we provide examples from the field of science in order to shed light on specific issues and growth in Indonesia's science education today. As a result, we provide context for understanding some of the challenges teachers face when attempting to implement a standard curriculum in so many different kinds of schools, with diverse students, and in vastly different learning environments. We describe the development of the national curriculum for science and the development of science textbooks in this paper.

Before entering high school, every student in the lower grades learns the fundamentals of science in elementary and middle school. When teaching science at these ages, there is no apparent difference between physics,chemistry, and biology material. At the elementary school level, science is taught three times per week for a total of around 105 minutes per week (Faisal & Martin, 2019). Approximately 200 minutes of science instruction per week is required for students in junior high school. Students who choose a science track in high school are given around 135 minutes per subject each week to devote to their studies. Students, for example, spend about 405 minutes a week in classes like Biology, Physics, and Chemistry. In addition to the lecture time, teachers at the senior secondary level can provide two additional lessons each week for each topic. Experiential learning such as demonstrations and assessments are best conducted during this time period. An overview of Indonesian high school Biology courses is provided here, so you can get a better sense of the breadth and complexity of what students learn in science classes in Indonesia (Faisal & Martin, 2019).

Critical Thinking in Malaysian Schools

Since the 1990s, critical thinking has been incorporated into the school curriculum. In spite of this, science teachers appear to be primarily concerned with teaching the knowledge/ information in the science subject. Smart thinking abilities have been incorporated into the curriculum tools such as evaporating clouds, cause-and-effect, and ambitious aim trees were developed by utilizing constraints theory (Khaw, 2005).

AIM, the Prime Minister's Department's innovation agency, is currently leading the charge to ensure that critical thinking is taught in schools. Thinking Maps were used in the i-Think pilot project, which involved 100 schools (AIM, 2014). Learning a new language can be as simple as creating a set of thinking maps to aid in the process. Thought maps can be used to brainstorm, contrast, and establish analogies. However, because it does not appear to cater for scientific procedures and reasoning skills, the thinking maps project may need to be changed. Learners must first have a working grasp of scientific language in order to understand scientific conversations. The learner is able to utilize scientific vocabulary and construct meaningful phrases and sentences to organize and explain his thoughts when he has a working grasp of scientific language. The student would be able to understand and engage in scientific debates at a higher level of language proficiency. The development of scientific concepts and principles will be dependent on the students' and teachers' patterning, modeling, and scaffolding for their communication abilities.

Critical Thinking in Indonesian Schools

Passive learning methods emphasizing only the repetition of concepts were prevalent in the previous educational system. Without questioning or examining the concepts, they had been well-trained in memorizing textbook material. There is no other way to become more critical, in our opinion, and challenging concepts. Preconceptions based on earlier schooling, such as the belief in good and evil, were also discovered. An all-or-nothing approach to thinking about public health would limit our ability to be critical. After the Reform Era in 1998, when Indonesians sought greater freedom to express themselves as citizens, critical thinking gained considerable traction in the country (Emilia, 2010). More critical thinkers who can sort through a variety of ideas and identify which ones are logically appropriate are needed to help our country advance following the reformation. That's why critical thinking is an important part of the Indonesian curriculum. Students in Indonesia are falling behind their classmates in other Southeast Asian countries like Singapore and Malaysia when it comes to critical thinking, according to a number of studies (Bridgstock, 2017; Beardsley et al., 2021). To help pupils develop their critical thinking abilities, we need to incorporate more critical techniques into our curriculum (Gustine, 2018). It is a part of practical skills to help individual in solving occurred problems (Tahrir et al., 2020).

A critical thinker is able to express his ideas in both written and spoken form. According to Barry (2007), better writing in social science is associated with better expression of more complex ideas. Instead of speaking, students had to learn to listen and read under the old curriculum. In the classroom, the teacher was the center of attention. Because of this setting, students have become complacent. Student participation in the new curriculum, which encourages critical thinking, has taken precedence. Discussions about topics students have previously studied are now encouraged (and often mandated) in the classroom. As a moderator, the teacher's role is to keep the presentation on topic.

Higher-Level Thinking Skills (HOTS) are among the many skillsets that the federal government hopes students to master. Think creatively, be innovative and self-assured are just a few of the skills you'll need to succeed in today's workforce (confidence). The government laid up a list of five items they were going to focus on. As a 21st century skill set, a student's moral character is inextricably linked to their performance on national exams. As a result of the country's poor performance on the PISA and TIMSS international assessments, an effort was made to raise the level of exam questions at the national level in order to catch up.

An educational program designed by the Ministry of Education and Culture (Ditjen GTK) in order to promote student learning and graduation quality has been dubbed Higher Order Thinking Skill (HOTS). Following the Ministry of Education and Culture's 2018 implementation of its policy direction, Strengthening Character Education and Learning Oriented to Higher Order Thinking Skills, this program was developed in compliance with that direction.

General Components of the Instructional System Design in Problem-Centered Thinking Skill (PCTS) Model for Science Lesson in Bandung, Indonesia and Selangor, Malaysia

In order to facilitate the growth of scientific knowledge, classroom activities in science should be communicative in nature. The following guidelines can help you create a solid foundation of knowledge. Learners struggle with science's terminology and linguistic structures, and teachers must be aware of this (Ellerton, 2003). The novice learner should be provided with more opportunities for patterning and modeling. Videos, simulation software, tutorials, and drill and practice software can also be used for this purpose. An important part of the teacher's duty is to provide individualized scaffolding, precisely tailored to the learner, as well as more opportunities to demonstrate the patterns of scientific language. As a result, acquiring communication skills for scientific discourse, such as active listening and speaking, is vital for scientific planning, communication, idea development, and critical thinking (Ellerton, 2003).

Problem activities should begin with easy tasks and progress to more complex ones in order to provide students with opportunity to apply their current knowledge. As a result, the student can customize his or her learning experience (Ellerton, 2003). Students in grades 8 through 10 can participate in scientific conversations, even if they're still in primary school (Brown, 2006; Greeno, 1992). It is, however, dependent on the students' comprehension of language, their drive, their views, and whether or not they have assimilated into the culture (Brown, 2006). Students should be given meaningful work that they find interesting and motivating. Students' participation in science learning activities has been bolstered by positive social connections (Brown, 2006; Cosgrove, & Schaverien, 1996; Greeno, 1992; Olitsky, 2007).

When this positive social connection for learning techniques is used in science classes, students' ability to reason scientifically improves. In addition to classroom instruction, these principles can be used in online education (Bridgstock, 2017). It is possible to use ICT to complete scientific projects via online discussion. A study comparing the results and characteristics of students from smart schools and non-smart schools shows that students from smart schools had considerably greater science process abilities than students from non-smart schools, which supports the idea that technology can promote science learning (MDeC, u.d.). The researchers made a significant impact on the science education technologies that are currently in use. In addition to this, the researchers had also warned that a "one size fits all" learning strategy was not appropriate. Learning had to be tailored to each individual student.

Instructional System Design in Problem-Centered Thinking Skill (PCTS) Model for Science Lesson in Bandung, Indonesia

The initial principles of teaching proposed by Merrill (2002) were design-oriented concepts that had an impact on student learning. There are many real-world applications for Merrill's concepts, and they can be applied in any delivery system. The four stages of learning should be taken into consideration when teaching: (a) activation of prior experience; (b) demonstration of skills; (c) application of skills; and (d) integration of these skills into real world activities (Merrill, 2002).

Problem

Learning is enhanced when students are actively engaged in solving real-world problems, according to Merrill's (2002) fundamental principles. According to Merrill (2002), this "Let me complete the whole assignment" approach is a problem-centered method in which students are presented and actively involved in solving real-world problems. To ensure that students achieve proficiency in problem solving, Merrill (2002) recommends that learners begin with easy problems and work their way up to more complicated ones. Tasks should be authentic, real-world, and personal in order to be meaningful, Merrill (2002) states. These challenges are more relevant to the student, which helps boost their confidence (Ausubel, 1968). (Keller, & Kopp, 1987).

Activating the learners' current knowledge is the first step in building new knowledge and skills, according to Merrill (2002). Then, new knowledge is displayed to the learner so that it can be applied and incorporated into the learners' reality.

Activation

the learner is asked to demonstrate and apply his or her past knowledge to new situations and experiences, which shows the relevance of the new knowledge, during the initial activation phase (Merrill, 2002). For this reason, in Gagne's events of teaching, the activation of past information is used in order to gain attention and recall preparatory knowledge (Gagne, 1970) to ensure learner preparation. Students' entering behavior is critical for designing the next phase of training. (Dick, & Carey, 1985). Students must make connections between what they are learning and what they already know (An et al., 2021) to ensure that what they are learning is useful (Baker-Doyle, 2017).

Demonstration

Learning should be demonstrated in a way that is consistent with its aims and information delivered during this demonstration or "show me" phase (Merrill, 2002). Concepts, procedures, and processes are taught using different instructional strategies, while suitable learner guidance approaches are used to guide students' attention, make use of numerous representations, and link new knowledge to previous structures throughout the activation phase. Use of appropriate media will aid in the learning process (Merrill, 2002; Merrill, 2007).

Presenting the stimulus material allows the learner to imitate the behavioral, cognitive, or attitudinal change in fourth event of instruction (Cavanaugh & DeWeese, 2020). Depending on whether conceptual, procedural, or theoretical elaboration necessitates the employment of summarizing, synthesising, or analogizing procedures, the structure of learning can be sequenced accordingly (Evans, 2019). There are a number of ways to illustrate learning, including positive and negative exemplars, counter instances, and other cases (Krishnamoorthy & Keating, 2021).

Application

When students reach the "let me do it" stage, they put what they've learned into practice by solving problems with it (Merrill, 2002). In order to meet the learning objectives, students need to practice on knowledge about (factual information), parts of (location, name and description), sorts of (concepts), how to (procedures) and what happens (process to forecast the outcomes of a process) (Merrill, 2007). To help students with their problem solving, scaffolding is used to provide corrective feedback and coaching while the learner tackles a series of different challenges. The scaffolding steadily diminishes with each job and is gradually withdrawn until the student is able to function on their own without any help (Merrill, 2007). An important part of instruction is eliciting student performance and providing direction and feedback as well as measuring student achievement at this stage (Gagne, 1970). With adequate scaffolding and participation from the student, it's possible to help them plan and build solutions to the problems they're facing. When faced with a challenge, the learner was able to create and evaluate hypotheses and consider various solutions (Collins, 1987). When the learner sees the connection between the activity he is familiar with and what he is expected to do, he gains confidence as he is challenged to perform and he expects to succeed (Keller, & Kopp, 1987).

Integration

During the "watch me" phase, students apply their new information and skills to their daily routines (Merrill, 2002). Students get the opportunity to demonstrate their newly acquired information and abilities in front of an audience while they reflect, debate, and defend them, as well as create, invent, and experiment with new applications for them (Merrill, 2002). Transfer of learning (Gagne, 1970) is ensured when the material is integrated into the students' own life experiences. Formalizing the learning experience requires the learner to reflect, synthesize, and evaluate the processes that took place during problem solving (Nelson, 1999). After Merrill (2009) revised his theory, he added a new section on implementation as part of the integration phase. Using features like course maps and navigation options on all screens, he believes that training should help learners avoid becoming lost. This would also provide students some degree of control over their own learning. Collaborative efforts should be framed so that they may be used effectively and training must be individualized for each learner, he said.

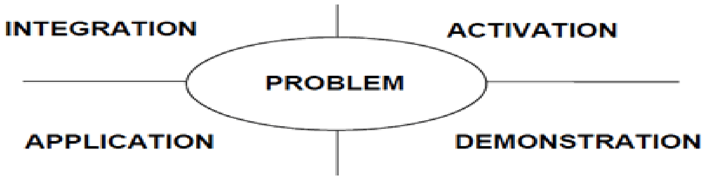

Figure 1
First principles of instruction, adapted from Merrill (2002)

In spite of the fact that the First Principles of Instruction is a problem-centered eclectic framework, no instructional model for solving problems appears to exist. A Problem-Centered Thinking Skill (PCTS) model for science reasoning in secondary school education is needed as a result of these findings.

Instructional System Design in Problem-Centered Thinking Skill (PCTS) Model for Science Lesson in Selangor, Malaysia

The social and cultural aspects of learning are taken into account in the social constructivist theory. Interaction occurs when students communicate with one another, with their tutors, and with the course materials themselves. Using science-based activities, students will be able to work together, educate one other, and build on each other's work in the classroom. Socio-constructivist theorist Lev Vygotsky is a prime example of the need of social discussion and interaction in internalizing cognitive processes. Vygotsky emphasized the value of a supportive social context in the development of cognitive skills (Brunings, Schraw, & Ronning, 1995; Schunk, 2000). Internal and external human components are brought together to develop learning in an environment (Brunings, et al., 1995; Schunk, 2000).

The use of cultural tools in the outside world aids in the growth of a person's capacity for critical thinking. Cars, pencils, and machinery, as well as more abstract social tools such as language and social organizations, including schools and churches, are examples of cultural instruments (Brunings, et al., 1995; Schunk, 2000). This cognitive change occurs when these cultural tools are used in social interactions, internalized, and processed (Brunings, et al., 1995). As a result, Vygotsky sees the learner's social interactions in a cultural environment as a source of cognitive processes (Brunings, et al., 1995).

However, there is a big difference between what a student can do and learn on his own, and what he can accomplish with the support of a professional.. Disparity between what pupils know and what an expert knows is known as the zone of proximal development. To put it simply, the ZPD is the distance between a child's ability to solve a problem on his or her own and the level at which the problem could be solved with the assistance of an expert (Brunings, et al., 1995). A certain level of proficiency can be achieved by the student with enough assistance.

Problem-centered learning, according to Jonassen (2013), can help students build skills that they can employ in a variety of contexts while they are engaged in cognitive activities. Using the First Principles of Instruction (Merrill, 2002) as a guide, Jonassen explained that addressing problems entails the four key processes of analogizing, modeling, reasoning causally, and argumentation (see Figure 3.2). That's what Jonassen, (2013) said would promote significant learning and should be completed for problem-solving, according to his findings.

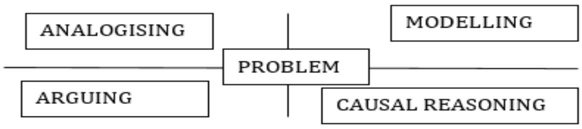

Figure 2
First principles of learning, adapted from Jonassen (2013)

The problem-centered approach to learning is supported by Jonassen's (2013) ideas. Students are challenged to think critically and creatively by presenting them with a realistic problem and a supportive learning environment. An M-learning module should provide students with a problem-based learning strategy to help them improve critical thinking and knowledge generation skills. The problem-solving procedures for learning can be explained using this approach.

DISCUSSION

It is via the use of scientific reasoning procedures (Abruscato, 2000) that new scientific information is generated, whether by a solitary scientist or a team of researchers. Higher order reasoning processes in science should not be overlooked because science is a combination of both the science content and the scientific and logical processes. According to Hogan and Fisherkeller (2005, p. 96), "science is a technique of reasoning about phenomena both alone and within a community of peers." Using scientific approach improves students' creative thinking in solving problems (Suarsana et al., 2019). To build scientific knowledge, scientists communicate and collaborate with each other utilizing science (Etkina, Mestre, & O'Donnell, 2005) and scientific methods. Because of this, science education should emphasize the importance of inquiry and communication in generating new information (Ford, & Forman, 2006).

To achieve Malaysia's Vision 2020, more critical thinkers and creative problem solvers are needed in the fast expanding sector of science and technology. With the help of the national education policy, Malaysia's national science education philosophy is focused on the development of "individuals who are competitive, dynamic, robust and resilient, and able to master scientific knowledge," as well as "scientific knowledge" and "technological competence. Science education's goals are to teach students scientific subject understanding; scientific methods, which include processes and skills; and a culture of science that encompasses social concerns, personal needs and career awareness. ICSS, Malaysia's science curriculum for secondary schools, places a high value on students' understanding of scientific processes and procedures.

Scientific Knowledge

Discoveries concerning the natural world made through scientific methods are the source of all scientific information and content (Abruscato, 2000). Knowledge of science in the classroom includes facts, concepts, and principles or laws (Abruscato, 2000). Direct observation is a primary source of some of these scientific facts, while higher cognitive and reasoning processes are used to confirm hypotheses or draw conclusions about what we see in the world around us. A number of teaching tactics are used in the science curriculum at the ICSS to promote the development of students' thinking skills, as well as their understanding of science, their mastery of scientific techniques, and their cultivation of scientific attitudes and noble ideals (MOE, 2002). A lot of science is covered in Form 2, however it must be taught via developing students' scientific and critical-thinking abilities.

Methods of Scientific Investigation

Methods of scientific inquiry are used to discover new knowledge in the field of science (Abruscato, 2000). Skills needed to carry out scientific research include observation; classification; use of spatial/temporal links; use of numbers; measurement; communication; hypothesizing; experimentation; controlling variables; interpretation of data; inference; inferring; and operationally (Abruscato, 2000; MOE, 2002). The scientific process necessitates not just proficiency with the steps of the scientific method, but also the ability to think critically and creatively. It is important to note that the scientific method includes both scientific techniques and the ability to think critically. The ICSS science curriculum divides scientific abilities into two categories: scientific process abilities and manipulating abilities (MOE, 2002). It is important that students learn how to think "creatively, critically, analytically and systematically" (MOE, 2002, p. 4), as well as how to use objects. Instead of focusing solely on facts and figures, the curriculum encourages students to apply their critical and creative thinking to solve issues (MOE, 2002). The scientific method incorporates these kinds of critical-thinking abilities (MOE, 2002). In order to obtain scientific information, one must be able to use both scientific and critical thinking skills.

Scientific Reasoning

The scientific thinking is defined as involving the inquiry skills that are utilized in the creation of hypotheses, experimentation or observation, and evaluation of data. Thus, inquiry learning was considered as a student-centered learning method where students actively participate in the development of knowledge through hypotheses, evidence collection, and the interpretation of results. As a result, several countries have adopted inquiry-based learning as a pedagogical strategy for enhancing students' capacity to reason and apply scientific ideas (Bybee, Trowbridge, & Powell, 2008).

Making hypotheses and deductions, as well as subpatterns such as recognizing the confusing findings; analogical reasoning to produce hypothesis and planned testing; and formal operational schemas showing linkages have been found to be a part of scientific thinking (Srisawasdib & Koulc, 2013). To be an effective scientist, one must be able to clearly state the problem at hand, devise a strategy to solve it, collect and analyze relevant data, and then interpret the findings.

The Lawson Classroom Test of Scientific Reasoning (LCTSR) has been used to measure scientific reasoning (Lawson, 2000). It was widely utilized and pre-validated to examine students' scientific reasoning abilities in six domains, including I Conservation of Mass and Volume (CMV), Proportional Thinking, Control of Variables, Probabilistic Thinking, Correlational Thinking, and Hypothetical-Deductive Reasoning.... (HDR). It should be noted that the LCTSR was first designed in 1978 and amended in 2000, and is still in use today. In the local community, it doesn't appear to be much of a thing. Inductive, deductive, and transitional reasoning are the only three reasoning styles that can be used with the LCTSR (Arslan, Göcmencelebi, & Tapan, 2009).

Critical Thinking

"An intentional and self-regulatory judgment that is concluded to interpretation, analysis, evaluation, and inference as well as explanations of many forms of arguments based on logical judgment," describes CT, according to Facione (1990) The "California Critical Thinking Disposition Inventory (CCTDI)," designed by Facione et al., has been used to measure critical thinking (1998). However, research by Haghparast, Nasaruddin, and Abdullah (2014) shows that critical thinking skills (CTS) can be assessed in the following areas: A conclusion can be drawn from evidence, observations, and opinions, which are all part of interpretation. A conclusion can also be drawn from interpretation, which includes categorization and understanding the question's meaning. A conclusion can also be drawn from analysis, which comprises the identification of arguments and questions. This includes (v) conveying the results, validating techniques and presenting arguments; and (vi) self-regulation: managing the emotions to rectify and self-examine oneself (Haghparast, Nasaruddin, & Abdullah, 2014).

The Bloom's taxonomy of educational objectives (1956), the Anderson and Krathwohl (2001) taxonomy which includes a metacognitive system, are only a few of the models for teaching CT (Dwyer, Hogan & Stewart, 2014). Can reasoning and critical thinking (CT) be accomplished using only the traditional methods? In the earlier models, some researchers have found that there is a lack of higher-order cognitive processes in these CT models (Dwyer, Hogan & Stewart, 2014). The lack of CT skills in science students despite years of inquiry-based training and a concentration on scientific processes (MOE, 2013). Inquiry-based education has failed to generate teachers and trainers who can teach CT skills in countries that adopt this methodology. As part of an infusion method and by weaving HOT into the content of science, it conducts semi-structured interviews with professionals in science teaching. Subject goals that seem to take precedence over thinking goals in implementation, along with issues acquiring pedagogical and content expertise. This includes (a) knowledge of individual thinking methods like making comparisons or drawing valid conclusions; (b) knowledge of genres of thinking like argumentation, inquiry learning and problem solving; (c) knowledge of critical thinking and scientific reasoning. d) awareness of a variety of additional topics that are critical for the successful "thinking classroom," such as thinking dispositions or habits of mind, and a suitable "culture of thinking" and knowledge of metacognition.

CONCLUSION

In Indonesia and Malaysia, the use of HOTS in critical thinking has led to the implementation of a new teaching method. Because of these variables, teachers and students appear to be making less progress in their learning activities than they have in the past. The new instructional science-learning paradigm should be adopted in Indonesian and Malaysian secondary schools in order to develop students' critical thinking skills focused on problem solving. Instructional design models that are used in both of these areas have a diverse set of general components and characteristics. PCTS Model for Science Lesson in Bandung, Indonesia includes the five basic steps of the instructional system design model that cover problem integration, activation, application and demonstration, while in Malaysia it involves five steps as well: problem analogizing modeling arguing and causal reasoning as well as causal reasoning and reasoning in terms of cause and effect. High-quality scientific learning activities for secondary school students will be made possible by these resources.

RECOMMENDATIONS

It is hoped that this finding would spur educational institutions to come up with new models for teaching science that students will find engaging. Thus, teachers and students will be able to meet their goals if they adhere to the rules of enhancing their higher-order thinking skills through critical and creative thinking in scientific learning.

This study also advises future research and development of a product in the form of a model with a critical thinking, reasoning skill, and problem-based solving base that can enable lecturers and students carry out more systematic and thorough scientific learning activities. This product's goal is to help learners improve their motivation and academic performance in science.

LIMITATIONS

This research has limitations, namely that it only involves respondents from two cities, namely Bandung-Indonesia and Selangor- Malaysia. Thus, the research results may not be able to reach a broader range of respondents in two countries. Besides, this study has limitations that only uses data triangulation, in which data is obtained through an interview process with several respondents.

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