Research Article

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The Effectiveness of Online Problem-Based Learning Tasks on Riyadh's Secondary School Students' Problem-Solving Ability and Programming Skills

https://doi.org/10.1515/edu-2022-0208
received May 16, 2022; accepted November 01, 2023

Abstract: This study aims to examine the effectiveness of online problem-based learning (PBL) tasks on problem-solving ability (PSA) and programming skills of secondary school students. A quantitative research design of a quasi-experimental research was adopted in this study. A purposive non-random sampling method was used to select two schools. Then, a clustered random sampling technique was carried out to select four classes, consisting of 120 students. The classes were divided equally into online PBL and non-online PBL. A problem-solving inventory questionnaire was used to measure PSA before and after the treatment, and pre-post performance tests were used to assess students' performance. The students underwent 8 weeks of learning tasks by using online PBL via Facebook groups. The findings from this study proved that online PBL improved students' PSA, and their higher-order thinking skills, and helped them to perform better in learning programming by using Facebook for interaction and participation in the online discussion with a facilitator and peers.

Keywords: distance education and online learning, secondary education, social media, teaching/learning strategies

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1 Introduction

Learning programming skills (PS) is not an easy task for those who are attempting to learn programming for the first time, as supported by many research studies (Mhashi & Alakeel, 2013). Novice programmers lack the knowledge and skills needed for programming, such as coding and debugging, yet these skills are essential to computer-related fields of study (Jawdah, 2015; McCracken et al., 2001; Mhashi & Alakeel, 2013; Taha, 2015). Indeed, one major goal for learning programming is to enhance students' problem-solving ability (PSA) by forcing them to break down a problem into its component pieces and reassemble it in a general format that can be more easily understood (Siegle, 2009; Uysal, 2014). Most freshmen students taking programming courses face difficulties due to a lack of ability to analyse problems (Gondim, Ambrósio, & Costa, 2011; Ismail, 2005).

The problem-based learning (PBL) approach in education is a well-known constructivist approach that has emerged in recent years as a potential alternative to the conventional approaches to computer science studies (Corrêa & Martin, 2014; Ekaterini, Spyros, & Panagiotis, 2003; Greening, Kay, Kingston, & Crawford, 1997). As a learner-centred instructional method, PBL involves thinking strategies, content knowledge learning by students, and also self-directed learning skills via experimental and facilitated learning, as well as problem-solving (Barrows, 2000; Hmelo-Silver, Duncan, & Chinn, 2007; Wang, Li, & Pang, 2016).

Based on Santos et al.'s (2018) study, PBL is a learning strategy that is commonly used by instructors for teaching computer programming courses. The effectiveness of PBL often contributes to positive learning processes and learning outcomes. Recently, PBL has been applied in online courses as a strategy to promote students' participation and interaction (Chagas, Faria, Mourato, Pereira, & Santos, 2012; Savin-Baden, 2007). According to Kumar and Rajendra (2012) and Sri Jothi, Neelamalar, and Prasad (2011), online software for social media offers a better learning experience through improved engagement and online discussions among students. For instance, Facebook offers a simple-to-use platform for interaction, allowing instant knowledge-sharing among students as well as between students and teachers anywhere and anytime.

The present study seeks to examine the effectiveness of online PBL tasks through Facebook for secondary school students who were enrolled in a Visual Basic (VB) programming course. Previous research clearly indicates that there is a relationship between computer programming courses and the PBL strategy, by which the PBL strategy makes a positive contribution to students' learning processes in programming courses (Ambrósio & Costa, 2010; Oliveira, Dos Santos, & Garcia, 2013). Therefore, it is believed that the proposed PBL methodology will motivate, stimulate, and develop students' ability to solve problems following its introduction as a teaching methodology (Ambrósio & Costa, 2010). Despite the potential of PBL as a learning strategy for programming courses, little is known about the effectiveness of online PBL towards students' PSA and PS. Thus, to fill this research gap, it is critical to understand the effectiveness of online PBL. Therefore, there is a need for research on PBL that is conducted through the online medium to enhance students' PS and PSA.

2 Operational Definitions

Several key terms will be used repeatedly in this study, as defined follows.

2.1 Problem-Based Learning

PBL is a dynamic learning technique based on the utilization of complex, ill-structured problems as a stimulus for cooperative learning (Barrows, 2000). In addition, it is an instructional, student-centred pedagogy in which students learn about a subject through the problem-solving experience, as it empowers students to conduct research and integrate theory and practice to develop a viable solution to a defined problem (Savery, 2006).

In this study, the researchers used the PBL definition proposed by Albion (2003), who stated that PBL is a powerful instructional design for professional education that can be used to lead an interactive multimedia (IMM) design. An IMM kit integrating the principles of PBL has been created to help teachers learn how to implement information and communication technologies (ICT) in their teaching. In other words, an IMM-PBL kit was planned and built to provide content related to incorporating ICTs into teaching in a web browser format (Albion, 2000a).

2.2 Problem-Solving Ability

Problem-solving is a useful term representing an attempt to find, discover, or invent a solution to a problem in a controlled manner (D'Zurilla & Nezu, 1999). As stated earlier, according to Heppner and Petersen (1982), the PSA has three dimensions: problem-solving confidence (PSC), approach-avoidance style (AAS), and personal control (PC). PSC can be defined as the person's trust in his or her own PSA. AAS refers to an individual's tendency for how he or she is going to solve a problem or avoid it, while PC is associated with the belief that the individual is in control of their decisions and emotions when engaging in problem-solving tasks.

To assess PSA among secondary school students, the researchers adapted the Arabic version of the problem-solving inventory (PSI) (PSI-Ar) created by Heppner and Petersen (1982) and translated by Alfiky and Alshennawy (1996). The PSI-Ar can be divided into three dimensions: PSC, which contains ten items, AAS, which includes twelve items, and PC, which consists of four items. The responses to the PSI-Ar items range between 1 (strongly disagree) and 4 (strongly agree). This measurement is used in two phases: first, a pre-PSI-Ar was conducted before students began to study the Computer and Information Technology 2 (CIT2) curriculum, and then, a post-PSI-Ar was given to the same students at the end of the curriculum.

2.3 PS

Programming is one of many important skills that students of computer science need to master (McCracken et al., 2001). An expected outcome of a student's education in programming courses is PS, which includes understanding a problem, writing a suitable computer program code, and debugging coding errors. In this study, the term "PS" refers to program design, coding, and debugging.

2.4 VB

VB is a popular programming language for creating applications with a graphical user interface, dialogue boxes, and menus, which run under different versions of Windows. VB has functions and tools for creating screen elements and programming language statements. Moreover, VB can create applications that work with databases and create web applications and applications that use Internet technologies (Gaddis & Irvine, 2011).

2.5 Coding

Coding is a statement written by a programmer that follows the syntax rules specified by the programming language (Ford, 2016).

2.6 Debugging

Debugging refers to any incorrect code discovered during programming test runs, which must be resolved by the programmer. Therefore, it is necessary to debug the code in any application to verify its runtime behaviour and to fix any issues that occur (Satheesh & Subashni, 2013).

2.7 Eleventh Grade

In Saudi Arabia, eleventh grade is a second year of secondary school; students are usually aged 16 years old in this grade level.

2.8 Online PBL

Online PBL is the use of PBL in an online environment such as Facebook. In online PBL, students are involved in small discussion groups consisting of four members and guided by a facilitator.

2.9 Non-Online PBL

Non-online PBL is a traditional approach of learning, which is teacher centred, where students are given lectures based on the CIT2 syllabus in the classroom. The teacher teaches the students what to do to complete the course.

3 Research Questions

The main questions of this study are as follows:

1. Is there any significant difference in PSA between Saudi secondary school students who use online PBL tasks through Facebook and those who use non-online PBL?
2. Is there any significant difference in PS between Saudi secondary school students who use online PBL tasks through Facebook and those who use non-online PBL?
3. What is the relationship between PSA and PS among Saudi secondary school students who use online PBL tasks through Facebook?

4 Theoretical Background

PBL is a learning approach that utilizes specialized content knowledge bases and loosely structured real-life problems within authentic contexts as the catalysts for learning (Savery & Duffy, 1995; Weigand, 2015). In this study, the researchers used online PBL as a learning strategy, adopting the nine principles of the online PBL learning model by Albion (2000b). It represents a substantial foundation upon which to construct an approach to the design of Albion's PBL (Albion, 2000a). Albion's works were also influenced significantly by Vygotsky's social constructivism learning theory (1978).

In this study, programming learning tasks are related to information technology integration. Those tasks should reflect the real teaching environment and a logical purpose with regard to the context of the scenarios (Albion, 2000b). In solving the tasks, students need to represent multiple viewpoints, and they are challenged to examine their knowledge and perceptions when they corroborate their viewpoints with other alternative thoughts (Albion, 2000b). Ill-structured problems involve conflicting viewpoints that may lead to several workable solutions (Toy, 2007). This means that there is no single correct solution for this task. In this sense, students need to interact with others in order to construct their own knowledge, which will lead them to generate an appropriate solution. In particular, social interaction results in the construction of knowledge, and communication plays a key role in promoting thinking (Vygotsky, 1978).

In this study, online PBL tasks were conducted through Facebook within small collaborative groups in which social interactions are critical for knowledge acquisition and successful problem-solving. This is consistent with Vygotsky's social constructivist view of learning, namely, that learning is best facilitated through the social negotiation of authentic tasks that mimic everyday life situations (Weigand, 2015).

5 Literature Review

5.1 Measuring Students' PSA

Problem-solving could be described as a process used when encountering problems that have no immediate apparent solution (Schoenfeld, 1992). Problem-solving is a higher-order intellectual skill that enables students to recall rules and put them immediately into effect if they master the skill (Gagne, Wager, Golas, Keller, & Russell, 2005; Jacob & Sam, 2008). One purpose of this study is to assess the current level of PSA before students start the CIT2 curriculum and then enhance PSA among secondary school students through online PBL tasks with Facebook groups.

Problem-solving is most appropriately conceptualized as a person's capacity to follow methods to overcome dilemmas experienced in everyday life activities (D'Zurilla & Nezu, 1999). PSA can be measured using several instruments, such as the Towers of Hanoi test by Edouard Lucas (Hinz, 1989) and the PSI by Heppner and Petersen (1982). The OECD-PISA test by the Organisation for Economic Co-Operation and Development–Programme for International Student Assessment can be used to evaluate mathematical problem-solving abilities with multi-degree complexity (Organisation for Economic Co-operation and Development, 2010). However, the PSI is more appropriate for the current study, as Alfiky and Alshennawy (1996) translated the PSI into Arabic for use with samples from Saudi Arabia, and they have demonstrated that it is a valid and reliable measure to use with the Saudi population.

The PSI is a self-report indicator of applied problem-solving that is widely utilized in different cultures and ethnic groups (Soliman, 2014). It has been used in more than 150 empirical investigations over 30 years of research (Heppner, Witty, & Dixon, 2004). The researchers found two different studies, conducted by Uysal (2014) and Yurdugül and Aşkar (2013), which used the PSI to measure the students' PSA on computer programming courses, and this measure has also been shown to be suitable for secondary school students (Huang & Flores, 2011; Nota, Heppner, Soresi, & Heppner, 2009). Moreover, the PSI has been used in several countries and various cultures. These studies provide growing evidence in support of the validity and reliability of the PSI in United States samples (Heppner & Petersen, 1982), as well as in other cultural contexts, such as Italy (Nota et al., 2009), French-speaking Canada (Laporte & Sabourin, 1988), Turkey (Akyuz & Keser, 2015; Uysal, 2014; Yurdugül & Aşkar, 2013), China (Cheung, 2002), Mexican America (Huang & Flores, 2011), Egypt (Soliman, 2014), the United Arab Emirates (Al-Darmaki, 2005), and Saudi Arabia (Alfiky & Alshennawy, 1996).

PSA among students can be assessed based on the PSI developed by Heppner and Petersen (1982). As mentioned earlier, PSA can be identified through three dimensions, which are PSC, AAS, and PC. The PSI total score is the sum of these three subscales. The PSI also aims to rank students as effective problem solvers in ways that reflect attitudes and actions usually associated with good problem solving and to increase their satisfaction with their PSA. Most of Heppner and Petersen's (1982) works reflect the constructivist learning theory.

5.2 Students' Performance in Coding and Debugging Skills

Owing to the rapid growth of technology in society, the nation needs programmers. Shortly, the demand for programmers seems likely to expand. Furthermore, even though some students might not have the ambition to become programmers, learning how to program would be helpful because of the number of devices and applications surrounding us. PS teaches students how to use computers and apps in a flexible manner (Boyer, Langevin, & Gaspar, 2008; Duncan, Bell, & Tanimoto, 2014; Hiltunen, 2016).

Students who are unable to read a short piece of code and understand it in a relational way are not qualified to write correct code (Lister, Simon, Thompson, Whalley, & Prasad, 2007). Moreover, novice programmers take little time preparing and checking their code and instead attempt to fix their programs with small local repairs; students also have difficulties with different issues related to the construction of programs (Dijkstra, 1989; Mhashi & Alakeel, 2013). Novice programmers commonly tend to be unable to remember programming instructions if they cannot successfully process and use these codes in meaningful instructional contexts (Uysal, 2014), whereas students can master programming languages and develop the ability to write their own programs if analytical and computational reasoning skills are at a high enough level. This is expected to contribute to improved prospects in the upcoming labour market (Hiltunen, 2016).

In Saudi Arabia, many studies (Alamri, 2014; Alferm, 2011; Alghamdi, 2014; Alhabashi, 2015; Alsheikhi, 2012; Mhashi &

Alakeel, 2013) have revealed that students who take programming classes for the first time have minimal levels of achievement in PS, especially in coding and debugging. Mhashi and Alakeel (2013) investigated the challenges that students face in mastering computer PS. Their results revealed that the students had low levels of performance in coding skills, as their English was very weak, and they were unable to solve problems. Similarly, Alamri (2014) reported that many students in secondary schools had low levels of coding and debugging skills, and they were incapable of writing program code according to problem-solving steps, even for simple programs such as Zakat and GPA projects. Another study conducted by Alsheikhi (2012) aimed to investigate the effectiveness of an educational software program proposal to provide high school students with PS in VB. The results revealed that most students are unable to write coding or even perform debugging due to their low performance in PS.

As a computer teacher, the main researcher has found that the computer and information technology curriculum is based on many fundamental skills. For example, solving a VB programming problem is one of the most essential basic skills in stage two of secondary school in Saudi Arabia. Typically, problem-solving contains several steps: analysing problem elements, writing the algorithm, drawing the flowcharts, choosing a programming language to write a program (coding), interpreting the program into assembly language (the compiler's job), and testing the program (by the computer) and then fixing its errors, which should be done by the programmer (debugging). These steps require skill enhancement in both theory and practice.

5.3 The Relationship Between Students' PSA and their Performance in PS

Writing a program requires students to use problem-solving skills, and thus, computer programming can be regarded as a type of problem-solving process (Uysal, 2014). Palumbo (1990) explored the inverse causal association of programming and problem-solving, that is, whether learning how to program develops problem-solving abilities among students. Pillay and Jugoo (2005) studied the student characteristics affecting the performance of novice programming at South African tertiary institutions; they noticed a positive correlation between PSA and programming performance. Koulouri, Lauria, and Macredie (2014) found that teaching problem-solving before programming yielded significant improvements in student performance. It may also be argued that the beneficial impact of early exposure to problem-solving on programming capacity occurs independently of the language used in the programming process.

Various researchers in Saudi Arabia have shown that students have low levels of PSA as well as low levels of PS, such as coding and debugging, when they attend programming courses for the first time (Alamri, 2014; Alsheikhi, 2012; Mhashi & Alakeel, 2013). However, a comprehensive study on the relationship between PSA and PS needs to be executed systematically to find out in detail the direction of the relationship. Further research needs to explore also the probability that PBL tasks enhance both the skills mentioned above for the benefit of students when learning a programming language.

5.4 Online PBL Through Facebook

Research on education via social media shows that including social media in teaching environments and education may result in new ways of research, engagement, communication, or identity activity or can have positive cognitive, emotional, and social effects (Gao, Luo, & Zhang, 2012; Greenhow & Lewin, 2016; Pimmer, Linxen, & Gröhbiel, 2012). For instance, research on e-learning and social media platforms, such as Facebook, has proposed their affordances for connectivity, cooperation, and the sharing of resources and knowledge (Mazman & Usluel, 2010); encouraging partnership and critical thinking (Ajjan & Hartshorne, 2008; Mason & Rennie, 2007); enhanced encouragement for and interaction with peers about the content of the course and its evaluation (DiVall & Kirwin, 2012); and their positive effects on the expression of identities and digital literacies (Manca & Ranieri, 2013).

Some studies have indicated that the appropriation of social media platforms may promote the convergence of formal and informal learning across learning scenarios (Dabbagh & Kitsantas, 2012). Many researchers have used the term "formal learning," which reflects the confines of the classroom and "informal learning," which covers everything else from school clubs to the home (Ranieri & Brun, 2013; Reynolds & Chiu, 2013).

A study conducted by Greenhow and Lewin (2016) at Michigan State University found that secondary school and college students engaged in vigorous, intelligent debates about scientific issues when using voluntary Facebook forums. The study sample comprised 322 users who voluntarily joined a Facebook app that dealt with subject-related science news. After analysing the students' activity on the app, the researchers found that their discussions on various science issues were on-topic.

Facebook is a tool to communicate in group discussions or independently (Phungsuk, Viriyavejakul, & Ratanaolarn, 2017). It provides students with chances to connect with peers meaningfully, receive timely feedback on questions or performances relevant to content, consider teammates as mentors, gain pleasure from contributing to something greater than themselves, and experience different perspectives.

6 Methodology

A quantitative research design was adopted in this study using a quasi-experimental research that involved quantitative data. These data were collected using a questionnaire and performance tests. This quasi-experimental design used a non-randomized control group design that involved a control group, and an experimental group that was chosen purposively; both were given a pre-test and post-test and, based on their test scores and other characteristics, were deemed to be reasonably equivalent (Campbell & Stanley, 1963). This study was conducted in secondary schools in Riyadh. The sample for this research comprised 120 male eleventh-grade students from Riyadh secondary schools, divided equally into control and experimental groups. The researchers selected two different schools (one school for the control groups and another for the experimental groups) to avoid interaction between students from the two groups.

6.1 Research Instruments

In this research, two types of instruments were used: questionnaires (PSI-Ar) to measure the current level of PSA; and students' performance tests (pre-test and post-test).

6.2 Validity and Reliability of PSI

The PSI was developed by Heppner and Petersen (1982) to measure students' PSA. The Arabic version of the PSI – the PSI-Ar – was used throughout this research, as it has already been translated into Arabic and standardized for the Saudi context by Alfiky and Alshennawy (1996). The Arabic version of the PSI consists of 26 items from the three underlying factors.

The original PSI scale was a six-point Likert-type scale for undergraduate university students (Heppner & Petersen, 1982). The PSI-Ar instrument consists of four-point Likert-type questions (1 = Strongly disagree to 4 = Strongly agree). The PSI-Ar was given to a sample of undergraduate students (Alfiky & Alshennawy, 1996). In this study, the researchers used the same scale with secondary school students, as respondents of this age might be more comfortable with a scale that consists of fewer response categories; this, in turn, had a positive influence on reliability because the students were able to respond more consistently. Moreover, many educators have recommended using a four-point, Likert-type scale that does not have a neutral point for students in elementary and secondary schools (Adelson & McCoach, 2010; Bourke & Frampton, 1992).

Cronbach's alpha value obtained by Alfiky and Alshennawy (1996) was 0.815, while the split-half reliability was 0.755, and the Guttman split-half reliability was 0.755. Although the reliability was estimated by different methods, and the reliability coefficient was high, the researchers also identified the value of Cronbach's alpha based on the sample for the pilot study. The results of the reliability test show that the overall reliability of the pre-PSI-Ar questionnaire is high, with a Cronbach's alpha value of 0.81. The reliability of the post-PSI-Ar questionnaire is also high, with a Cronbach's alpha value of 0.80.

6.3 Validity and Reliability of Pre- and Post-Performance Test

In order to validate the pre- and post-performance tests, the researchers conducted tests of expert validity to check the validity of the pre- and post-performance tests, as well as the learning tasks. He sought validation of the learning tasks from Professor Peter Albion, who created the scenario development for devising problems in an online environment that is used in this study. The pre- and post-performance tests were validated by two experts in the computer field.

On the other hand, the researchers conducted the test-retest reliability by repeating the post-performance test with the students two weeks later to confirm that the instrument was reliable over time. The result indicated that there is a moderate positive correlation between post-test in week 2 and week 4 ($r = 0.61$, $n = 12$, $p = 0.033$) based on the interpretation of the correlation coefficient provided by Dancey, Reidy, and Using (2004).

6.4 Data Collection

In this phase, the researchers conducted the main experiment over the duration of one semester. Initially, in the first week, all students filled in the pre-PSI-Ar questionnaire and took the pre-performance test. They completed the questionnaire in class time, which took them between 20 and 25 min. Subsequently, the students in the experimental groups received the treatment (PBL tasks), which was conducted by using online PBL through Facebook groups.

The facilitator had an important role in online PBL during this experiment, as the transition from the traditional instructional method to online PBL presents significant challenges. In this phase, the facilitator in this study for the online PBL group was the researcher, and he followed the roles stated by Albion (2000a, 2010): to facilitate the development of students' thinking and their independence as learners rather than providing content through lectures; to act as a metacognitive guide for developing students' thinking; to facilitate the group process by modelling higher order thinking (HOT) and challenging students' thinking; to model the processes of lifelong learning; to act as a resource, not as a knowledge dispenser, consistent with twenty-first century learning; and to provide less information than in the traditional approach.

In conducting this research, the researchers formulated the research protocol by following the procedure of this research systematically to avoid experimenter bias. The research conducted several validations when analysing the data in order to reduce the potential for experimenter bias. First, the researchers performed the validation of the learning via online PBL tasks from Professor Peter Albion, who is an expert in PBL and created the scenario development framework. The pre- and post-performance tests were validated by two experts in the computer science field. Furthermore, "inter-rater reliability" was used to reduce the potential bias of the raters when they were collecting and analysing data. The researchers conducted the inter-rater reliability in order to measure the reliability of the VB coding transcript from each Facebook group that was used to define the level of HOT skills, which reflected the PS achieved by students. Moreover, in order to measure the inter-rater reliability of the development of students' PS by using online PBL tasks through Facebook, the teacher in computer science was selected as a second rater. This coding aimed to define the learning behaviour posted by students in online discussions through Facebook groups.

Lastly, to prevent the Hawthorne effect, the main researcher was introduced to the students as the facilitator's assistant; hence, the students were unaware that they were involved in an experiment. Furthermore, the researcher did not inform the students that they were being observed during their interaction through Facebook groups. In addition, as mentioned earlier in the roles of facilitator stated by Albion (2000a, 2010), the researcher did not act as a knowledge dispenser, and he provided less information during the experiment to avoid experimenter bias.

6.5 Non-Online PBL Tasks

Students in the control group studied the CIT2 syllabus in the school using the traditional approach to learning, which is teacher-centred. In this approach, the teacher teaches students the theoretical part in the classroom and teaches them the practical element in the computer laboratory. Students need to follow teacher instructions in order to accomplish these VB tasks.

6.6 Online PBL Tasks

In this study, the researchers designed and developed eight online PBL tasks. These tasks were ill-structured programming problems. Students had to complete each task in a one-week period. Therefore, in order to accomplish the given PBL tasks, students needed diverse skills, including HOT and PSA. The researchers designed these tasks by following the project scenario development devised by following the criteria of scenario development for PBL tasks set out by Albion and Gibson (1998). As stated earlier, this scenario contains the following elements: concepts, context, artefacts, storyline, and scenario.

7 Findings and Discussion

7.1 Students' PSA Between those Who Use Online PBL Tasks Through Facebook with those Who Use Non-Online PBL

The first research question aimed to identify the difference in students' PSA between those who were using online PBL tasks through Facebook (experimental group) and those who were using non-online PBL (control group). To provide more details about the respondents, a descriptive analysis of the demographic information was gathered from the PSI questionnaire. Table 1 shows the students' demographic data.

Based on Table 1, most of the students were 16 years old (71.7–76.7%). The number of students who had a personal computer at home was almost the same in both groups (66.7–70.0%), while the percentage of students who had programming experience in the control group

Table 1: The Distribution of Respondents' Age from PSI questionnaire Among Control and Experimental Groups

	Respondents' age categories	Control Group		Experimental Group	
		n	%	*n*	%
Age	15	8	13.3	5	8.3
	16	43	71.7	46	76.7
	17	8	13.3	6	10.0
	More than 17	1	1.7	3	5.0
	Total	**60**	**100.0**	**60**	**100.0**
Have a personal computer at home	Yes	40	66.7	42	70.0
	No	20	33.3	18	30.0
	Total	**60**	**100.0**	**60**	**100.0**
Programming experience	Yes	16	26.7	8	13.3
	No	44	73.3	52	86.7
	Total	**60**	**100.0**	**60**	**100.0**

was 26.7 versus 13.3 in the experimental group. Besides that, concerning the analysis of students' PSA, all of the participants in the two groups were asked to complete the PSI-Ar questionnaire before and after taking the CIT2 course.

7.2 PSA

The overall PSA in the experimental group was quite similar to the overall PSA in the control group in terms of the pre-test, while the overall PSA of the experimental group in the post-test was higher than the overall PSA in the control group as shown in Figure 1.

Figure 1 illustrates the mean of the PSC, AAS, PC, and the overall PSA between the control and the experimental group in the pre-test and post-test. As shown in this figure, the PSA was quite similar in both groups in terms of the pre-test. The PSA in the experimental group including the three sub-constructs, which are PSC, AAS, and PC, is higher than in the control group. The mean of post-PSC for the experimental group was 3.19, which is higher than the post-PSC for the control group. Likewise, the mean score for the

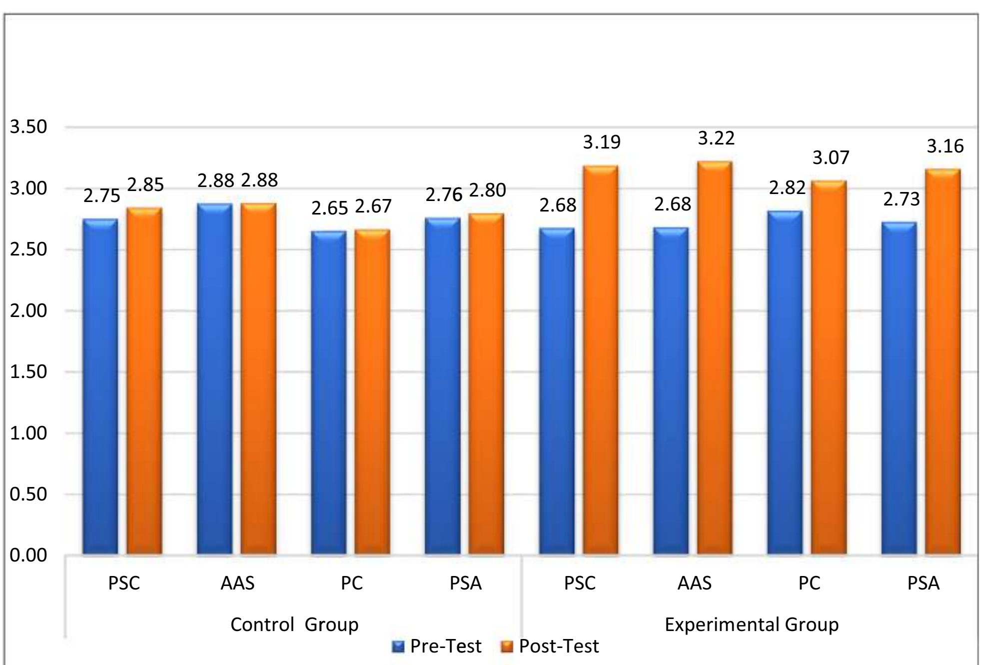

Figure 1: Students' PSA for Both Control and Experimental Groups.

post-AAS in the experimental group was 3.22, which is higher than the mean of the post-AAS for the control group. The mean score of post-PC in the experimental group was 3.07, which is higher than the mean of the post-PC for the control group. In turn, the post-PSA in the experimental group was higher than that in the control group.

7.3 Quade's ANCOVA Test for Post-PSI Between the Control and Experimental Groups

In order to know if there is any significant impact on the PSA in post-PSI between the control and experimental groups, the non-parametric test of ANCOVA, namely, Quade's ANCOVA test, was conducted to examine any significant differences between these groups. Table 2 illustrates the result of Quade's ANCOVA test.

As seen from Table 2, the results of Quade's ANCOVA test reveal that there is a significant difference between the control and experimental groups in the post-PSI questionnaire in all PSA factors, and the total PSA was in favour of the experimental group. The results revealed that [$F(1,118) = 33.86$, $p = 0.000$] for PSC, [$F(1,118) = 31.49$, $p = 0.000$] for AAS, [$F(1,118) = 33.24$, $p = 0.000$] for PC and [$F(1,118) = 98.59$, $p = 0.000$] for total PSA. The F value for PSI is 98.59 with a significant value is 0.000 less than 0.05, indicating a significant difference between the control and experimental groups in the post-PSI questionnaire ($p < 0.05$) test in favour of the experimental group. In other words, this finding indicates that the treatment given to the experimental group is found to have had a significantly positive impact on the students' PSA. The partial Eta Squared value is $\eta^2 = 0.223$ for PSC, $\eta^2 = 0.208$ for AAS, $\eta^2 = 0.220$ for PC, and $\eta^2 = 0.455$ for PSA, which indicates a large effect size for all PSA subscales, along with the overall PSA based on the benchmarks suggested by Pallant (2007), as illustrated in Table 3.

This result showed that the treatment indicating a substantial difference in the PSA scores obtained in the post-PSA test between the control and experimental groups in favour of the experimental group. This indicates that online PBL tasks had a significant influence on students' PSA.

7.4 Wilcoxon Signed Ranks Test for Comparison Between Pre-PSA and Post-PSA within the Experimental Group

This section describes the findings of the Wilcoxon Signed Ranks Test for comparison between pre-PSA and post-PSA within the experimental group. Table 4 illustrates the p-

Table 3: Effect Size Interpretation Guidelines

Size	Eta Squared (% of variance explained)
Small	0.01 or 1%
Medium	0.06 or 6%
Large	0.138 or 13.8%

Source: Pallant (2007).

Table 2: Result of Quade's ANCOVA Test of Control and Experimental Groups in the Post-PSI Questionnaire with the Pre-PSI as a Covariate for All PSA Factors

Tests of Between-Subject Effects							
Dependent Variable: Unstandardized Residual							
Source	**PSA Factors**	**Type III Sum of Squares**	**df**	**Mean Square**	***F***	**Sig.**	**Partial Eta Squared**
Corrected Model	PSC	30918.447a	1	30918.447	33.86	0.000	0.223
	AAS	27563.168a	1	27563.168	31.49	0.000	0.208
	PC	30810.552a	1	30810.552	33.24	0.000	0.220
	PSA	63909.533a	1	63909.533	98.59	0.000	0.455
Intercept	PSC	0.000	1	0.000	0.000	1.000	0.000
	AAS	0.000	1	0.000	0.000	1.000	0.000
	PC	0.000	1	0.000	0.000	1.000	0.000
	PSA	0.000	1	0.000	0.000	1.000	0.000
Group	PSC	30918.447	1	30918.447	33.86	0.000	0.223
	AAS	27563.168	1	27563.168	31.49	0.000	0.208
	PC	30810.552	1	30810.552	33.24	0.000	0.220
	PSA	63909.533	1	63909.533	98.59	0.000	0.455

Table 4: Results of Wilcoxon Signed Ranks Test for Comparison between Pre-PSA and Post-PSA within the Experimental Group

Experimental group		Mean Rank	Sum of Ranks	*z*	*p*-value	*r*
Post-PSC – Pre-PSC	Positive Ranks	34.99	1696.00	6.13	0.00	0.56
	Negative Ranks	8.05	74.00			
Post-AAS – Pre-AAS	Positive Ranks	31.03	1657.50	6.21	0.00	0.57
	Negative Ranks	20.50	53.50			
Post-PC – Pre- PC	Positive Ranks	27.11	947.50	3.00	0.00	0.27
	Negative Ranks	21.73	327.50			
Post-PSA – Pre-PSA	Positive Ranks	33.07	1785.00	6.41	0.00	0.59
	Negative Ranks	7.33	45.00			

value in each dimension of PSA and the overall PSA in the experimental group.

Table 4 shows the results of the Wilcoxon Signed Ranks Test (the nonparametric test for paired *t*-test), which reveal that all dimensions of PSA and the overall PSA of the experimental group are significantly different before and after the treatment ($p < 0.05$), with an overall large effect size 0.59 according to Cohen's (1988) guidelines. The mean score of the post-PSI questionnaire is higher than the pre-PSI. The effect size interpretation was measured based on Cohen's (1988) guidelines, as illustrated in Table 5.

The results showed that all three subscales of the PSI-Ar, which are PSC, AAS, and PC, are higher in the online PBL group than in the non-online group in terms of post-test. The PSC represents the students' self-confidence while engaging in problem-solving activities (e.g., "When faced with a novel situation, I have confidence that I can handle problems that may arise" [Huang & Flores, 2011; Nota et al., 2009]). The AAS refers to a general tendency to solve or avoid a vast range of problem-solving activities (e.g., "When confronted with a problem, I do not usually examine what sort of external things in my environment may be contributing to my problem" [Nota et al., 2009]). The PC is defined as a student's belief that an individual is in control of their own emotions and behaviours while solving problems (e.g., "Even though I work on a problem, sometimes I feel like I am groping or wandering and am not getting down to the real issue" [Nota et al., 2009]).

Table 5: The Guidelines of the Effect Size Interpretation

Size	Relative size
Small	0.1
Medium	0.3
Large	0.5
Very large	0.7

Source: Cohen (1988).

The mean for the online PBL group in this study was 3.16 for the PSA total, and 3.22, 3.19, and 3.07 for the AAS, PSC, and PC, respectively (refer to Figure 1). In other words, students in the online PBL group were more confident about solving a problem (PSC score), were more likely to problem-solve (AAS score), and had PC over the problem-solving process (PS score).

The results of this study are in line with previous studies by Argaw, Haile, Ayalew, and Kuma (2017), Abdul Kadir (2013), Finkelstein, Hanson, Huang, Hirschman, and Huang (2011), Oliveira et al. (2013), Siregar, Asmin, and Fauzi (2018), Sulaiman (2011) and Wilder (2015), which demonstrated that PBL as an instructional approach can promote the development of PSA among students. Moreover, similar findings were found by Phungsuk et al. (2017) and Qomaruddin, Rahman, and Lahad (2009) whereby the use of PBL through an online medium enhanced problem-solving skills among students. According to Bennedsen, Caspersen, and Kölling (2008), the PBL method is appropriate for learning problem-solving skills, and the group interaction within the PBL group supports this.

In this study, the researchers used the scenario development created by Albion and Gibson (1998) for crafting the online PBL tasks. Albion integrated the problem scenarios for teaching with ICTs (Albion, 2000a). From the findings of this study, the researchers contributed that Albion's scenario development to create online PBL tasks can be utilized in the programming field, specifically in VB language. These PBL tasks enhance PSA among secondary school students; however, to date, there have been no studies examining how PSA evolves among secondary school students by using online PBL tasks through Facebook in learning VB. Moreover, the finding from the PBL tasks created by the researchers expands the terms established by Albion, as the researchers developed PBL tasks that can be applied through social media platforms such as Facebook while Albion utilized PBL tasks in e-learning (Albion, 2000a). On the other hand, the researchers used the nine principles of the online PBL learning model by Albion

(2000b) in order to improve students' PSA for those who study programming. Whilst these principles were used by Albion as the basis for the design and development of integrating information technology into teaching (Albion & Gibson, 1998), Albion did not reveal explicitly the relationship between PBL and PSA specifically in learning VB.

7.5 Students' PS Between those Who Use Online PBL Tasks Through Facebook and those Who Use Non-online PBL

This section addressed the second research objective, which is to analyse the effectiveness of online PBL tasks through Facebook on PS among Saudi secondary school students. Therefore, the pre-test and post-test were used to measure their achievement in PS for the control and experimental groups. Table 6 indicates the pre-test and post-test for those who used the online PBL tasks compared to those who used the non-online PBL tasks. Moreover, this table provides a descriptive analysis of the control and experimental groups in the pre-test and post-test. As shown in this table, the mean score of the pre-test for both groups was almost identical. In comparison, the mean score of the post-test for the experimental group who used online PBL tasks via Facebook was 17.56 higher than the control group's mean score for those who used the non-online PBL medium. It is apparent from this table that the minimum score for both groups in the pre-test was completely symmetrical, which is zero grade. The student who achieved the maximum score, that is, 30, was in the experimental group and had the treatment. In turn, the maximum score in the control group was 19.50.

Based on the students' performance in the pre- and post-tests, which represent students' PS, there was a significant difference in the online PBL vs. the non-online PBL group. The finding from this study showed that online PBL significantly enhanced the students' PS. This improvement in students' PS might be due to the benefit derived from learning tasks through Facebook that have been crafted using the scenario development of PBL tasks by Albion and Gibson (1998). This is aligned with the findings from Baharudin and Harun (2014); they argued that PBL in the online environment might assist students in improving their understanding of programming language and their performance.

Table 6: Descriptive Analysis of Students' Mean and Standard Deviation, Minimum and Maximum Scores in Pre-Test and Post-Test Across the Experimental and Control Groups

Test Type	Control				Experimental			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Pre	0.49	0.90	0.00	3.50	0.48	0.58	0.00	3.00
Post	6.41	4.25	1.50	19.50	17.56	6.19	9.25	30.00

7.6 Quade's ANCOVA Test on Post-Performance Test Between the Control and Experimental Groups

Table 7 illustrates the *F*-value of Quade's ANCOVA test for the post-performance test between the control and experimental groups with the pre-test as a covariate.

As shown in Table 7, [$F(1,118) = 155.734$, $p = 0.000$] F value is 155.734 with a significance value of 0.000, which is

Table 7: Quade's ANCOVA Test Results for the Post-Performance Tests Between the Control and Experimental Groups with the Pre-PSI Test as a Covariate

Tests of Between-Subject Effects						
Dependent Variable: Unstandardized Residual						
Source	Type III Sum of Squares	df	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	77147.544[a]	1	77147.544	155.734	0.000	0.569
Intercept	0.000	1	0.000	0.000	1.000	0.000
Group	77147.544	1	77147.544	155.734	0.000	0.569
Error	58454.987	118	495.381			
Total	135602.531	120				
Corrected Total	135602.531	119				

[a] R Squared = 0.569 (Adjusted R Squared = 0.565).

less than 0.05, indicating a significant difference in students' scores between the control and experimental group in the post-performance test in favour of the experimental group. This means students who studied CIT2 through online PBL tasks showed an improvement in their PS. This finding supports the statement by Janpla and Piriyasurawong (2018), who revealed that implementing PBL and concept mapping by using a block-based programming model could enhance programming competency. Moreover, the results of Bennedsen et al. (2008) showed that a measurable benefit of this learning method was that it had a much lower drop-out rate than in traditional programming courses, with 17% versus 45%. Both the students of the PBL course and the students of the traditional programming courses subsequently went on to take the same advanced course in Java programming. The average scores for the students coming from the PBL course have been slightly better. In the end, the researchers think that the online PBL method can be successfully applied in an introductory programming course in order to improve students' PS and PSA.

The partial Eta Squared value is $\eta^2 = 0.569$; this is more than 0.138, which indicates a large effect size according to Pallant (2007). This result shows that the treatment led to a substantial difference in the scores obtained in the post-performance test between the online PBL group and non-online PBL groups in favour of the online PBL group. This indicates that the online PBL tasks had a significant influence on students' PS, which are design, coding, and debugging.

7.7 Wilcoxon Signed Ranks Test on Pre-Performance and Post-Performance Within the Experimental Group

This section describes the findings of the Wilcoxon Signed Ranks Test for comparison between pre-performance and post-performance within the experimental group. Table 8 illustrates the results.

The table, which shows the results of the Wilcoxon Signed Ranks Test (the non-parametric test for a paired *t*-test), reveals that the difference between pre-tests and post-tests in the performance test with the experimental group is significant with ($p < 0.05$), with a large effect size of 0.62 according to Cohen's (1988) guidelines. In other words, there is a significant difference in PS between the pre-tests and post-tests in favour of the post-test.

Based on the findings, the researchers successfully expanded the use of the online PBL learning model by Albion (2000b) to social media platforms such as Facebook in order to enhance students' PS, while Albion's model focused on online PBL through e-learning. Besides, based on the online PBL task results, the researchers demonstrated the validity and effectiveness of using the scenario development of PBL tasks by Albion and Gibson (1998) in crafting programming tasks that can be used in computer science in order to boost design, coding, and debugging skills, while Albion and Gibson illustrated how to apply it for teaching with ICTs (Albion, 2000a).

Furthermore, the finding of this study is in line with Bennedsen et al.'s (2008) study, as they stated that the PBL method works well to help students learn some aspects of PS, such as including program design skills, and group interaction within the PBL group supports this.

Such a finding was probably due to students' interaction with the online PBL learning tasks in order to solve the problems, which were created based on Albion's and Gibson's (1998) elements of crafting problems. This result is consistent with Yurdugül and Aşkar's (2013) research, which found that male students' development of their coding skills in a programming course might be attributed to their problem-solving skills.

This study was also able to reconfirm and support the effectiveness among Saudi's secondary school students of PBL in the inculturation of HOT among students, specifically in learning VB through Facebook. The theory underpinning PBL is a constructivist learning theory that frequently mentions the suitability of PBL as one of the learning methods that exposes students to HOT. When PBL tasks were implemented through Facebook, the social constructivist learning theory was referred to as the core theory that guided the study. The finding also again reconfirms the effectiveness of social constructivist learning theory in enhancing students' level of thinking.

Table 8: Wilcoxon Signed Ranks result for comparison between pre-performance and post-performance within the experimental group

Group	Test	Ranks	Mean Rank	Sum of Ranks	*z*	*p*-value	*r*
Experimental	Post- performance–Pre- performance	Positive	30.50	1830.00	6.736	0.000	0.62
		Negative	0.00	0.00			

7.8 Analysis of the Relationship Between Problem-Solving Ability and PS among Students Who Use Online PBL Tasks Through Facebook

To find the relation between the post-PSA and post-performance test (PS), the non-parametric Spearman's rho correlations analysis was used. Table 9 shows the result of the relationship between the post-PSA and post-performance test within the experimental group.

Table 9 shows that all the correlation coefficients (r) between post-PSA and post-performance tests within the experimental group are significant with a p-value <0.05 or less, and ranged between a moderate relation with a coefficient (r = 0.356) for the relation between post-AAS and post-performance test, and a very strong relation with a coefficient (r = 0.861) for the relation between the overall mean score of the post-PSA questionnaire and the mean score of the post-performance test based on Akoglu's (2018) guidelines. Therefore, there is a significant relationship between PSA and PS among students who use online PBL tasks through Facebook.

The finding from this study is in line with findings by Yurdugül and Aşkar (2013), which reported a significant relationship between problem-solving skills and programming knowledge, whereas the higher the level of problem-solving skill the student had, the more the level of programming knowledge increased over time. In other words, the reason for the development of students' ability to design a program interface and then write a suitable code, as well as to debug the errors, might be that students' problem-solving skills had improved. Moreover, this finding demonstrated that there is a link between PS and HOT.

Table 9: Spearman's Rho Correlations Result between Post-PSA and Post-Performance Test within the Experimental Group

Spearman's rho		Post-Performance Test
Post-PSC	Correlation Coefficient	0.648**
	Sig. (two-tailed)	0.000
	N	60
Post-AAS	Correlation Coefficient	0.356**
	Sig. (two-tailed)	0.005
	N	60
Post-PC	Correlation Coefficient	0.674**
	Sig. (two-tailed)	0.000
	N	60
Post-PSA	Correlation Coefficient	0.861**
	Sig. (2-tailed)	0.000
	N	60

**Correlation is significant at the 0.01 level (two-tailed).

When the student is able to design an interface for the program, that means he might have achieved the analysis level of Bloom's taxonomy. Then, when the student is able to write a suitable code that should run the application correctly, that indicates that he could be able to achieve the synthesis level (Alshaye, Jumaat, & Tasir, 2018; Lister & Leaney, 2003). Lastly, when the student has the ability to evaluate the programming code and then debug the errors, that means he might be able to achieve the top level of Bloom's taxonomy, which is the evaluation level (Alshaye et al., 2018; Satheesh & Subashni, 2013).

Another similar finding was found in Koulouri et al.'s (2014) study; they found that teaching problem-solving before programming yielded significant improvements in student performance. It could also be argued that the positive effect on the programming ability of early exposure to problem-solving arises independently of the language used in the programming course. A similar finding was found in Pillay and Jugoo's (2005) study where they studied the student characteristics affecting novice programming performance at South African tertiary institutions; they found a positive correlation between PSA and programming performance.

This research findings have confirmed the ideas proposed by some previous researchers and educational psychologists that PSA has a significant positive correlation with PS (Allan & Kolesar, 1996; Ismail, 2005; Koulouri et al., 2014; Malik, 2016; Unuakhalu, 2009; Yurdugül & Aşkar, 2013).

8 Implication

The findings of this study have certain positive implications for all who are involved in the process of teaching and learning in schools, as set out below.

8.1 Students

Computer programming is a difficult course that involves complex activities. In Saudi Arabia, students start to learn programming in the second year of secondary school by taking a CIT2 curriculum. The findings from this study proved that online PBL improved students' PSA and helped them to perform better in learning programming by using Facebook as a social media platform for interaction and participation in online discussions with a facilitator and peers. Moreover, the findings from Facebook showed that online PBL encouraged the students to improve their HOT skills, especially their analysis and synthesis levels.

8.2 Facilitators

Computer facilitators in Saudi Arabia should be trained in how to prepare and design programming tasks by following the scenario development that is appropriate for use in an online PBL medium. Therefore, these well-designed tasks will enhance the PSA and PS among students.

The findings of the study demonstrated that the facilitator has an important role in an online PBL environment. Facilitators often encounter major challenges when transitioning from traditional instructional methods to online PBL and to facilitating discourse and direct instruction to guide students' learning via Facebook groups.

8.3 Ministry of Education

The results of online PBL tasks through Facebook will assist policymakers in the Ministry of Education in Saudi Arabia to take a step towards the integration of technology and to approve the implementation of online PBL for educational benefits.

Based on the findings of this study, the researchers would suggest the MOE develop a new learning and teaching approach that can be utilized to teach a computer science curriculum such as CIT1, CIT2, and CIT3 in secondary schools. The outcome of this study can help to integrate online PBL with these curricula. Thus, students would be able to learn effectively and foster their PSA and PS. To nurture the use of online PBL in teaching, the MOE can provide facilitators with programs that have the specific intention to promote students' success.

9 Conclusion

Since no research has been done to explore the relationship between how PSA (PSC, AAS, and PC) and PS (design, coding, and debugging) evolve among secondary school students by using online PBL tasks, and no Saudi study to date has explored the real connection between PSA and PS, the findings of this study have contributed to knowledge about the relationship between PSA and PS among Saudi secondary school students who use online PBL tasks.

This study has shown that online PBL tasks have a positive impact on secondary school students' PSA and PS. The findings revealed that PSA among the online PBL group was higher than PSA among the non-online PBL group based on the post-test results. Furthermore, the online PBL promoted the PS among the online PBL group of students and helped them improve the mean score of the post-test compared with the non-online PBL group. The results of this study indicated that there is a significant relationship between PSA and PS among students who use online PBL tasks through Facebook.

Interestingly, the findings from this study add a piece of new information that previous studies had not been able to clarify, specifically, that having a high score in PSA will increase the students' PS when the students learn through online PBL tasks via Facebook. More than that, the previous studies suggested that PBL is effective in fostering students' development of appropriate PSA. Excitingly, the result of this study demonstrates that online PBL also has a positive impact in enhancing PSA whereas previous researchers have focused on PBL per se and not online PBL.

The outcomes of this study have added new knowledge about the effectiveness of online PBL tasks towards developing PSA and PS. It showed that online PBL tasks had a significant influence on students' PSA and PS. Therefore, the computer science curriculum should be focused on student-centred learning strategies, and learning tasks should be applicable to the experiences of students and be suitable for fostering successful learning, problem-solving skills, and HOT skills. Furthermore, the researchers would encourage the Ministry of Education in Saudi Arabia to develop a new learning and teaching approach based on online PBL tasks that can be utilized to teach a computer science curriculum that is relevant, engaging, and challenging for the students based on at the secondary school stage. Furthermore, the researchers believe that online PBL is an effective learning strategy, for teaching programming since it encourages problem-solving, HOTs, and self-directed learning in students from diverse backgrounds and circumstances. As a result, the researchers suggest that other facilitators investigate the possibilities of online PBL projects for computer science education in their respective contexts and share their results and experiences with the wider community.

Acknowledgements: Not applicable.

Funding information: No external funding.

Conflict of interest: Authors state no conflict of interest.

Data availability statement: Not applicable.

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