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A Meta-Analysis On The Impact Of Peer Instruction On Students' Learning

Pei Syan Woo, Mohd Rustam Mohd Rameli*, Azlina Mohd Kosnin

Faculty of Social Science and Humanities, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

*Corresponding author: mrustam2@utm.my

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Abstract

Peer instruction (PI) is an interactive teaching strategy that has been widely implemented in a variety of disciplines and institutions to improve students' learning through discussions and collaboration among peers. The main objective of this study paper is to provide an overview of the impact of PI on students' learning in cognitive and affective domains. The methodology was carried out based on a literature review search strategy through an online database of ERIC and other web-based service providers such as ScienceDirect, Springer Link, IEEE Xplore Digital Library and Google Scholar. The keywords used in the search included peer instruction, peer instruction in primary school, peer instruction in secondary school and peer instruction in higher education. The results of this meta-analysis revealed that most studies tend to focus more on the cognitive domains as PI could enhance students' achievement, problem-solving skills, conceptual understanding, learning gain as well as critical and creative thinking skills. For affective aspects, students perceived greater satisfaction along with a positive shift in attitudes and beliefs. Most studies were focused on students at the tertiary level and were mainly conducted in the western contexts. The findings from this meta-analysis will give a clear picture to educators regarded the benefits of implementing PI to achieve a successful teaching and learning process.

Keywords: Peer instruction, cognitive, affective, meta-analysis

Abstrak

Peer instruction (PI) ialah strategi pengajaran interaktif yang telah dilaksanakan secara meluas dalam pelbagai disiplin dan institusi untuk meningkatkan pembelajaran pelajar melalui perbincangan dan kolaborasi di kalangan rakan sebaya. Objektif utama kajian ini adalah untuk memberi gambaran tentang kesan PI terhadap pembelajaran pelajar dalam domain kognitif dan afektif. Metodologi ini dijalankan berdasarkan strategi carian kajian literatur melalui pangkalan data dalam talian ERIC dan penyedia perkhidmatan web lain seperti ScienceDirect, Springer Link, Perpustakaan Digital IEEE Xplore dan Google Scholar. Kata kunci yang digunakan dalam carian termasuk peer instruction, peer instruction di sekolah rendah, peer instruction di sekolah menengah dan peer instruction di pendidikan tinggi. Dapatan meta-analisis ini menunjukkan bahawa kebanyakan kajian lebih fokus kepada domain kognitif kerana PI boleh meningkatkan pencapaian pelajar, kemahiran menyelesaikan masalah, pemahaman konsep, perolehan pembelajaran serta kemahiran berfikir secara kritis dan kreatif. Bagi aspek afektif, pelajar menunjukkan kepuasan yang lebih besar seiring dengan perubahan positif dalam sikap dan kepercayaan. Kebanyakan kajian tertumpu kepada pelajar pada peringkat pendidikan tinggi dan dijalankan dalam konteks barat. Dapatan daripada meta-analisis ini akan memberi gambaran yang jelas kepada para pendidik tentang faedah pelaksanaan PI untuk menjayakan proses pengajaran dan pembelajaran.

Kata kunci: Peer instruction, kognitif, afektif, meta-analisis

1.0 INTRODUCTION

Traditional teaching methods are defined as the teacher-centred approach in which students rely heavily on the teacher's instruction and passively acquire the facts and knowledge presented in the classroom (Zhang, Kang & Li, 2013). The traditional teaching methods have been widely used to instruct students in a variety of disciplines and courses (Kaymak, Balta, Almas, Kazmagambet & Mbala, 2020). Studies found that students struggle with various difficulties in conceptual learning, problem-solving, generating relationships and representing knowledge while using these traditional methods (Aldarmahi, 2016; Crouch, Watkins, Fagen & Mazur, 2007). Freeman et al. (2014) further claimed that students were 1.5 times more likely to fail in their studies when they were taught using the traditional teaching methods. In the current world, the teaching and learning process continues to undergo a paradigm shift from a teacher-centred approach to a student-centred learning approach to meet the challenges in the 21st century (Schleicher, 2012). According to Indriani (2016), this shift places high expectations on teachers to use active and interactive teaching methods to encourage students' participation in the classroom. Recent researchers claimed that there are various new teaching approaches and models being introduced to complement or improve the traditional teaching methods (AbdulRaheem, Yusuf & Odutayo, 2017; Aidoo, Boateng, Kissi & Ofori, 2016; Aji & Khan, 2019; Akanmu, 2019; Demirci, 2017; Kizkapan & Bektas, 2017; Orji & Ogbuanya, 2020; Shaheen, Alam, Mushtaq & Bukhari, 2015). Therefore, interactive teaching methods are perceived as a proactive approach to diversify and promote students' learning in the classroom. Peer instruction (PI) is one of the interactive teaching methods that are effective in impacting students' learning, particularly in cognitive (Carstensen, Kjaer, Möller & Bloksgaard, 2020; Versteeg, van Blankenstein, Putter & Steendijk, 2019) and affective domains (Budini,

Marino, Carreri, Cámara & Giorgi, 2019; Zhang, Ding & Mazur, 2017). In general, most of the previous research studies have focused on the impact of PI on overall students' learning (Balta, Michinov, Balyimez & Ayaz, 2017; Tullis & Goldstone, 2020; Vickrey, Rosploch, Rahmanian, Pilarz & Stains, 2015). However, there is a lack of research examining the impacts of PI on students' learning particularly in both cognitive and affective domains. According to Baker (2012), the cognitive domain of learning involves knowledge and intellectual skills, whereas the affective domain relates to emotional and attitudinal involvement with the subject material.

2.0 PURPOSE OF THE STUDY

The conceptualization of the paper is to provide an overview of the impact of PI on students' learning in cognitive and affective domains. By assessing these two domains, educators can adjust their instruction, so that PI can be effectively implemented in the teaching and learning process.

3.0 LITERATURE REVIEW

Peer Instruction

Peer instruction (PI) is defined as an interactive teaching strategy that encourages classroom interaction to engage students to understand and uncover difficult aspects of the learning material (Crouch & Mazur, 2001; Mazur & Watkins, 2010). It was initially developed by Eric Mazur to teach introductory physics courses at Harvard University using conceptual multiple-choice questions (Mazur, 1997). PI has been shown to promote students' learning in a wide variety of academic disciplines and educational levels ranging from primary school to university (Balta et al., 2017). PI is an active student-centred learning strategy that provides the opportunity for students to construct knowledge and understanding through discussion with peers (Kwan & Wong, 2015). In PI, the traditional lecture format is modified by including conceptual questions to uncover student misconceptions (Vickrey et al., 2015). The Force Concept Inventory (Hestenes, Wells & Swackhamer, 1992) is used as the standardized instrument in PI to evaluate how effectively students understand a concept (Crouch et al., 2007). After finishing a simple lecture, students are required to answer a conceptual question individually. Students are given 1 to 2 minutes to think and vote their responses using a flashcard or a personal response system. If the majority of students answered inaccurately, students have to discuss the questions with their peers and vote again on their responses. Finally, students received explanations from the instruction about the correct and incorrect answers (Crouch & Mazur, 2001; Mazur, 1997).

Theory Underlying Peer Instruction

Peer instruction is an active learning strategy that works based on two main theories: social constructivism and constructivist learning theory (Gok, 2017). Social constructivism claimed that social interaction plays a vital role in the construction of knowledge and understanding (Schreiber & Valle, 2013). In peer instruction, students collaborate and discuss with peers to construct their own understanding of knowledge (Michinov, Morice & Ferrières, 2015). On the other hand, the constructivist environment in peer instruction is designed to facilitate students' thinking and support their involvement in the classroom. Students have the opportunity to take charge of their learning instead of being spoon-fed by the instructors (Yaoyuneyong & Thornton, 2011).

4.0 METHODOLOGY

Meta-analysis is a statistical method that systematically combines and synthesizes data from various research studies to draw a single statistically powerful conclusion (Balta et al., 2017; Salkind, 2010). The author conducted a narrative review of the literature for this meta-analysis. A narrative review is often descriptive, and it synthesizes non-numerical data in a systematic manner that allows researchers to determine what they want to meta-analyze (Jerzembek & Murphy, 2013; Xiao & Watson, 2019). In this study, an online database of Educational Resources Information Centre (ERIC) and other web-based service providers such as ScienceDirect, Springer Link, IEEE Xplore Digital Library and Google Scholar were used to search pertinent published articles. The keywords used in the search process of relevant studies include peer instruction, peer instruction in primary school, peer instruction in secondary school and peer instruction in higher education. In the beginning stage, there was no restriction on searching relevant studies such as research papers, conference papers, seminar papers, concept papers, thesis works and technical reports. Therefore, the search found about 108 papers which stated about PI. In the second stage, the number of related prior studies found was reduced to a total of 26 which fulfilled these criteria: (1) The studies focused on PI as described by Mazur (1997); (2) The studies published between 2014 to date; (3) The studies focused on primary, secondary and tertiary levels; (4) The impact of PI on students' learning in cognitive and affective domains. Some articles retrieved during the process of searching were not included in this study as the impacts of PI on students' learning were not explicitly stated in the titles, keywords, or abstracts.

5.0 RESULTS

Table 1 summarizes the research studies related to PI that have been conducted at the primary, secondary and tertiary levels. The analysis of the impacts of PI on students' learning was classified into two categories: cognitive and affective domains. The results showed that 1 study was found at the primary level, 8 studies were found at the secondary level and 17 studies were found at the tertiary level.

Table 1: The impacts of PI on students' learning in cognitive and affective domains

No	Study	Cognitive	Affective	Discipline	Level	Country
1	Pavlin and Campa (2021)	Knowledge; Understanding		Science and Technology	Primary	Slovenia
2	Atasoy, Ergin and Şen (2014)		Attitudes	Physics	Secondary	Turkey
3	Ouko, Aurah and Amadalo (2015)	Achievement		Mathematics	Secondary	Kenya
4	Ouko and Aurah (2015)		Attitudes	Mathematics	Secondary	Kenya
5	Antwi, Raheem and Aboagye (2016)	Conceptual understanding; Problem solving		Physics	Secondary	Ghana
6	Wang and Murota (2016)	Technical creativity		ICT	Secondary	China
7	Awinoouko (2018)	Problem solving		Mathematics	Secondary	Kenya
8	Kaviza (2021)	Achievement; Retention		History	Secondary	Malaysia
9	Nuri, Serkan, Abdullah and Omarbek (2021)	Achievement		Mathematics	Secondary	Kazakhstan
10	Gok (2014)	Conceptual understanding; Problem solving		Physics	Tertiary	Turkey
11	Gok (2015)	Achievement; Problem solving		Physics	Tertiary	Turkey
12	Michinov et al. (2015)	Learning gain	Satisfaction	Chromatography	Tertiary	France
13	Gok and Gok (2016)	Conceptual understanding; Learning strategies; Problem solving		Chemistry	Tertiary	Turkey
14	Zhang et al. (2017)		Attitudes; Beliefs	Introductory Physics	Tertiary	China
15	Bian et al. (2018)	Achievement		Medical Physiology	Tertiary	China
16	Kannan and Gouripeddi (2018)	Critical thinking		Engineering Physics	Tertiary	India
17	Teixeira, Teixeira, Silva, Mota and Barroso (2018)	Achievement		Linear Algebra	Tertiary	Brazil
18	Alcalde and Nagel (2019)	Achievement	Satisfaction	Applied Algebra for Economics and Business	Tertiary	Chile
19	Budini et al. (2019)		Perceptions	Introductory Physics	Tertiary	Argentina
20	Bulut (2019)	Achievement; Creative Thinking		Social Studies	Tertiary	Turkey
21	Perez, Ortega-Alvarez and Streveler (2019)	Learning gain		Physics	Tertiary	Colombia
22	Versteeg et al. (2019)	Conceptual understanding		Medical Physiology	Tertiary	Netherlands
23	Carstensen et al. (2020)	Achievement		Pharmacology	Tertiary	Denmark
24	Kaymak, Balta, Almas, Kazmagambet and Mbala (2020)	Achievement		Mathematics	Tertiary	Kazakhstan
25	Mitsuhashi (2020)	Conceptual understanding		Science and Medical Education	Tertiary	Japan
26	Gopal and Cooper (2021)	Learning gain	Attitudes	Computer Science	Tertiary	United States

6.0 DISCUSSIONS

The discussions of the findings in this study are divided into three parts: (i) impacts of Peer Instruction at the primary level; (ii) impacts of Peer Instruction at the secondary level and (iii) impacts of Peer Instruction at the tertiary level.

Impacts of Peer Instruction (PI) at the Primary Level

Based on the meta-analysis between 2014 and the middle of 2021, only one study had been conducted at the primary school level. Based on the study conducted by Pavlin and Campa (2021), PI was found to be effective in addressing students' science knowledge and understanding through multiple-choice questions and subsequent peer discussions. According to Crouch and Mazur (2001), PI is initially used for teaching undergraduate students at Harvard University to learn physics courses. A survey of the literature conducted by Vickrey et al. (2015) found that 67% of PI taught at universities, 28% taught at colleges, and 5% taught at high schools. The findings showed that the implementation of PI at the primary school level was extremely rare. This might be due to the application of PI requiring deeper exploration and analysis of course concepts (Vickrey et al., 2015), which is more appropriate for elder age students. Pavlin and Campa (2021) found that active participation and immediate feedback from PI discussions allow primary school students to understand and acquire knowledge more effectively. The evidence showed that not only tertiary and secondary level (Antwi et al., 2016; Gok, 2014) students benefited from the use of PI, but primary school students also showed progress in their knowledge and understanding of science concepts. However, the impact of PI on students' knowledge and understanding at the primary level was evaluated solely based on the percentage of questions that students answered correctly before and after the implementation of PI in the classroom. Meanwhile, standardized tests were used to measure students' knowledge and understanding of science concepts at the tertiary level before and after using PI in the classroom.

Impacts of Peer Instruction (PI) at the Secondary Level

Based on the meta-analysis, it was found that PI has been used in teaching mathematics (Awinoouko, 2018; Nuri et al., 2021; Ouko et al., 2015; Ouko & Aurah, 2015), physics (Antwi et al., 2016; Atasoy et al., 2014), ICT (Wang & Murota, 2016) and history (Kaviza, 2021). Only 8 out of the 26 studies had discussed the implementation of PI at the secondary school level. For the cognitive domain, PI showed multiple impacts on students' learning as it played a crucial role in developing students' achievement (Kaviza, 2021; Nuri et al., 2021; Ouko et al., 2015), problem-solving skills (Antwi et al., 2016; Awinoouko, 2018), conceptual understanding (Antwi et al., 2016), retention (Kaviza, 2021) and technical creativity (Wang & Murota, 2016). For the affective domain, two studies indicated that PI could positively impact students' attitudes by actively engaging them in peer-group activities (Atasoy et al., 2014; Ouko & Aurah, 2015). However, no study had been carried out to examine the impacts of PI on students' learning in both cognitive and affective domains at the secondary school level. This might be due to researchers did not give much emphasis on the affective aspects of students' learning. According to Kaklauskas et al. (2015), both cognitive and affective learning are integral aspects of a whole that cannot be separated. However, many educators place a strong emphasis on the cognitive domain while neglecting the affective domain (Taneri, 2017). According to the meta-analysis, only 7 out of 26 studies assessed the impacts of PI on students' learning in the affective domain, in which 2 studies from the secondary level (Atasoy et al., 2014; Ouko & Aurah, 2015) and 5 studies from the tertiary level (Alcalde & Nagel, 2019; Budini et al., 2019; Gopal & Cooper, 2021; Michinov et al., 2015; Zhang et al., 2017). According to Allen and Friedman (2010), people often disregard the affective domain because this domain is very personalized and difficult to evaluate. Furthermore, the widespread use of standardized tests and their application across all fields of study caused the affective domain to receive less and less attention (Montessori, Rafni, Irawadi & Unung Verawardina, 2021).

Impacts of Peer Instruction (PI) at the Tertiary Level

Based on the meta-analysis, 17 out of the 26 studies showed that PI was implemented in various disciplines such as Physics (Budini et al., 2019; Gok, 2014, 2015; Kannan & Gouripeddi, 2018; Perez et al., 2019; Zhang et al., 2017), Chemistry (Gok & Gok, 2016; Michinov et al., 2015), Medical and Health Sciences (Bian et al., 2018; Carstensen et al., 2020; Mitsuhashi, 2020; Versteeg et al., 2019), Mathematics (Kaymak et al., 2020; Teixeira et al., 2018), Computer Science (Alcalde & Nagel, 2019; Gopal & Cooper, 2021) and Social Studies (Bulut, 2019). For the cognitive domain, a total of 10 studies investigated students' achievement as their primary objective, which 3 studies from the secondary level (Kaviza, 2021; Nuri et al., 2021; Ouko et al., 2015) and 7 studies from the tertiary level (Alcalde & Nagel, 2019; Bian et al., 2018; Bulut, 2019; Carstensen et al., 2020; Gok, 2015; Kaymak et al., 2020; Teixeira et al., 2018). Students' achievement is the most frequent impact discussed by researchers at the secondary and tertiary levels. 9 out of 10 studies found that PI showed positive impacts on the students' achievement in various disciplines. Only 1 study found that PI did not significantly impact students' achievement (Nuri et al., 2021). The ineffectiveness of PI on students' achievement may be attributed to students simply selecting the most frequent response or just changing their ideas depending on the agreement of nearby students, rather than learning through PI (Perez et al., 2010).

Besides, students' conceptual understanding (Gok, 2014; Gok & Gok, 2016; Mitsuhashi, 2020; Versteeg et al., 2019) was found to be improved positively as PI helped students to understand the fundamental concepts through questions and answers on the subject discussed. One of the key factors that influenced the impact of PI on students' conceptual understanding was the effectiveness of the concept (Mitsuhashi, 2020). The concept tests were designed to provide additional insight into students' learning by allowing them to explore essential concepts and exposing typical problems with the topic (Crouch & Mazur, 2001; Mitsuhashi, 2020). Other than that, PI also showed a positive impact on students' problem solving skills (Gok, 2014, 2015; Gok & Gok, 2016) as PI helped students in logically monitoring problem solving procedures. Studies also revealed PI was effective in producing significantly greater learning gains among students compared to the traditional chalk and talk method (Gopal & Cooper, 2021; Michinov et al., 2015; Perez et al., 2019). Next, students' critical and creative thinking skills (Bulut, 2019; Kannan & Gouripeddi, 2018) were also enhanced as students' participation in group discussions allowed them to address difficult questions with better cognitive strategies as well as logical progressions.

For the affective domain, only one study assessed the impact of PI on students' perceptions (Budini et al., 2019). Students instructed with PI were found to exhibit higher satisfaction (Alcalde & Nagel, 2019; Michinov et al., 2015), and positive attitudes and beliefs (Zhang et al., 2017) towards learning. In comparison to the conventional teaching method, students found PI to be a more satisfying, engaging, and effective method that could lead to positive attitudes and beliefs (Michinov et al., 2015; Zhang et al., 2017). From the meta-analysis, only 3 out of 26 studies investigated the impacts of PI on students' learning in both cognitive and affective domains, and

all 3 studies were conducted at the tertiary level (Alcalde & Nagel, 2019; Gopal & Cooper, 2021; Michinov et al., 2015). These studies indicated that PI had a positive impact on students' learning in both cognitive and affective domains. According to Oppong (2014), cognitive and affective domains are crucial in every educational pursuit as they seek to indicate how well a student will perform in a certain subject. Therefore, it is necessary to utilize both cognitive and affective domains in the use of PI in students' learning.

■7.0 CONCLUSION

The study results showed most studies tend to focus more on the cognitive domain as PI could enhance students' achievement, problem-solving skills, conceptual understanding, learning gain as well as critical and creative thinking skills. Meanwhile, students also benefit from the affective aspects such as perceived greater satisfaction along with a positive shift in attitudes and beliefs. The findings also showed that most of the studies were mainly conducted at the tertiary level and focused on the western contexts. In summary, the significant role of PI in both cognitive and affective domains should be highlighted so that students' learning in various disciplines can be improved. This study encourages future researchers to examine the impacts of PI on students' learning based on statistical analyses to provide more detailed guidelines for educators to improve teaching practice in the classroom. Furthermore, local studies on investigating the impact of PI on students' learning are also highly encouraged to be conducted in the Malaysian context.

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