PEDAGOGICAL AGENT ELEMENT AND DESIGN FOR LEARNING: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Research on pedagogical agent can be tracked as early as 70s.Ever since that researcher on the field come with mixed opinion on its usage towards multimedia learning. Among the argument is that it will impose cognitive overload towards learner. This systematic review has been carried out on 17 research of pedagogical agent and its impact towards learner's cognitive load. Guided by PRISMA statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses), using resources from Scopus and Web of Science databases. Three main themes and eight sub-themes have been identified on pedagogical agent elements and its impact on learner's cognitive load. Several recommendations are highlighted related to direction for the future studies where elements in multimedia design principles should be explore more as it gives positive impact on learner's cognitive load upon implemented in pedagogical agent design. Apart from it there should be guidelines on how to implement these principles and elements when developing a pedagogical agent for multimedia learning.

Keywords: Pedagogical agent, cognitive load, multimedia learning.

1.0 INTRODUCTION

Pedagogical Agent is an entity that exist digitally in the learning program that serves as a tutor throughout the learning process. Researcher has been giving several terms and definition of pedagogical agent such as intelligence agent with pedagogical agenda(Haake, 2009), anthropomorphic virtual character(Martha & Santoso, 2019) It may vary in term of form and representation. Nevertheless, it carries the same objective which is to deliver pedagogical agenda throughout learning process. Research in pedagogical agent can be trace back as early as 70s where it start from another research discipline namely intelligent tutoring system(Gulz & Haake, 2006). From that, it evolved and equipped with newly added features that distinguish it from intelligent tutoring system(W. L. Johnson, Shaw, & Ganeshan, 1998). Its roles not only as teacher but also a tutor, a companion and peer throughout the learning(W. L. Johnson & Lester, 2018). However, implementation of pedagogical agent in learning, does not guaranteed significant improvement in learning. Review on pedagogical agent intervention shows that pedagogical agent intervention does not leave significant impact on learning (Heidig & Clarebout, 2011; Martha & Santoso, 2019). Even worse, it may hinder the learning process. There are several claims made on pedagogical agent that it imposes negative effect on the learning. Among the effects is it burden the learners cognitive load upon engaging with pedagogical agent (Clark & Choi, 2007).

Cognitive load are types of loads that impose on the learners cognitive upon engaging with learning material such as pedagogical agent. These processes happened in the human working memory.

Cognitive load theory by Sweller (2010) are the most common theory used to explain cognitive load in instructional learning. According to cognitive load theory, Human cognitive load can be categorized into three different loads namely, intrinsic load, extraneous load, and germane load. These loads will be optimized by human cognitive architecture during learning, to process information before it will be stored in the long term memory and become new knowledge(Kalyuga, 2009). The main objective of implementing pedagogical agent in learning is to enhance learning and improve the learning process. That is why pedagogical agent has been given multiple roles rather than mere tutor. However, an ill-designed pedagogical agent may hinder the learning and defeat the purpose of having pedagogical agent in learning process. Understanding elements and key features of pedagogical agent that cause cognitive overload may contribute to effective implementation of pedagogical agent in learning.

2.0 PEDAGOGICAL AGENT RESEARCH REVIEW

Systematic Literature Review or often goes with abbreviation SLR, is an examination of several paper that have been identified, selected and analyzed to answer a formulated question relevant to the research(Dewey & Drahota, 2016). A set of requirements will be determined to explicitly select type of research and data to be analyzed. A method of analyzing data will be established to analyzed finding of the included research. Systematic literature review allows the authors to justify thoroughness of the research and opening to chances of discovering gaps of the research and future research opportunities.

Researcher has been investigated and argued on effectiveness of pedagogical agent towards learning. While some researchers agreed that pedagogical agent impose positive impact towards learning, some others might have a different ideas(Schroeder & Adesope, 2014). Thus, there are several reviews have been done on pedagogical agent research studying on its effectiveness towards learning and impact it imposes on the learners(i.e;Guo & Goh, 2015; Martha & Santoso, 2019; Schroeder & Adesope, 2014; Schroeder, Adesope, & Gilbert, 2013). Cognitive overload, seems to be a concern on how pedagogical agent may create a drawback in learning(Clark & Choi, 2007). Despite the benefit of pedagogical agent towards learning, it may also create drawback in term of learner's cognitive load. Efforts to investigate and review the research on what cause cognitive overload upon intervention of pedagogical agent are still lacking in numbers. Developing a pedagogical agent for learning purposes will take up some amount of time and energy from the educator. However, an ill-designed pedagogical agent will hinder the learning rather than improve the learning. Therefore, this review aimed to identify important element of designing pedagogical agent that will contribute to the benefit of learning. This study is vital as it may prevent the pedagogical agent from impose cognitive overload towards learner by eliminating unnecessary element and features in the pedagogical agent development process.

Research question was established beforehand, to construct a proper systematic review. Thus, this paper was guided with a research question of -**What are the elements of pedagogical agent that cause cognitive overload upon intervention of pedagogical agent in learning?** The focus of the study was on the elements involved in designing and developing pedagogical agent. The study was targeted on implementation of pedagogical agent in the context of learning as it is the main focus of the role of pedagogical agent (Schroeder et al., 2013). Elements involved in developing pedagogical agent might and might not cause cognitive overload towards learner depending on how the element included in the pedagogical agent design.

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3.0 METHODOLOGY

This section will be focusing on the method used to retrieve article related to implementation of pedagogical agent in learning and its impact of learner's cognitive load. This paper utilized resources from Scopus to run a systematic review. Method called PRISMA, is used by the reviewer to identify relevant paper by defining the eligibility and the exclusion criteria. The review was undergone identification (article related) process and followed by data abstraction and analysis.

3.1 PRISMA

PRISMA is an abbreviation of Preferred Reporting Items for Systematic reviews and Meta-Analyses. Since it has been introduce, It has become the most cited guidelines used in systematic review especially in biomedical literature(Sarkis-Onofre, Catalá-López, Aromataris, & Lockwood, 2021). Due to its efficiency, other field of study such as e-learning and pedagogical agent learning also have been referring to the same guidelines(PRISMA) in making of a systematic review(i.e.,Castro-Alonso, Wong, Adesope, & Paas, 2021; Coskun & Cagiltay, 2021). Among the advantages of PRISMA guidelines are 1) it defines a clear research question that lead to a systematic research and 2) it identifies clear criteria for inclusion and exclusion of paper that needed to be reviewed(Sierra-Correa & Kintz, 2015). Thus, the PRISMA guidelines allows for rigorous search of terms related to the implementation of pedagogical agent in learning and its impact of learner's cognitive load review.

3.2 Resources

The main databases used for this review came from two main databases namely Scopus and Web of Science. Scopus was created in 2004 by Elsevier. As of October 2019, Scopus database consist of more than 23,000 journals that came from multiple discipline and a total of about 77.8 million core records. Web of Science , which is owned by Clarivate Analytics is older database compare to Scopus and as of 2020, it covers more than 74.8 million scholarly data and datasets (Singh, Singh, Karmakar, Leta, & Mayr, 2021). Without any doubt, these two databases seen to be the most suitable resources for the reviewed article.

3.3 Systematic Review Process

3.3.1 Identification

There are four stages involved in the review process. This Review was performed in June 2020. The first stage is to identify explicit keyword used for the search process using the database stated. Keywords were identified by relying on the past studies (Table 1) and thesaurus. Based on that, keyword similar and related to pedagogical agent and cognitive load were used (Table 2).

Table 1. List of Keywords

Keywords	Researcher
Pedagogical agent, teachable agent	(Martha & Santoso, 2019)
Pedagogical agent, conversional agent	(Schroeder & Adesope, 2014)
Pedagogical agent, virtual human, embodied pedagogical agent	(Davis, 2018)

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Embodied agent, pedagogical agent	(Guo & Goh, 2015)

Table 2. Search string

Databases	Search string
Scopus	TITLE-ABS-KEY(("pedagogical agent*" OR "teachable agent*" OR "conversational agent*" OR "embodied pedagogical agent*" OR "embodied agent*") AND ("cognitive load"))
Web of Science	TS=(("pedagogical agent*" OR "teachable agent*" OR "conversational agent*" OR "embodied pedagogical agent*" OR "embodied agent*") AND ("cognitive load"))

3.3.2 Screening

The next process is screening. In this process, all the article retrieved will be filtered out according to the eligibility and exclusion criterion that has been determined. The flow of screening the article can be seen in Figure 1. First criterion is the literature type. As for this criterion (literature type), the eligibility is journal with empirical data and all other types such as review article, book, conference proceeding, chapter in book are all excluded. Second criterion is language. To avoid any bias or misinterpretation of the reviews journal, the systematic review will only focus on article paper that use English language and Malay language. All other languages will be excluded from the list of reviewed articles. Third criterion, in regards of timeline, a period of 6 years is selected between 2015 and 2020. This to exclude any obsolete research and finding as parallel with technological advance, most of technological based research will tend to become obsolete after 5 years. Since this review fall under the category of social science, it means that type of index that will be used is Social Science Citation Index will be used and article published in hard science index will be excluded from the list. Lastly, although there are several research on the impact of pedagogical agent in learning, this systematic review will be focusing on the specific impact which is cognitive load. Therefore, upon screening, paper with unrelated content will also be excluded from the list.

Table 3 Eligibility and exclusion criterions

Criterion	Eligibility	Exclusion
Literature type	Journal (research articles)	Journals (systematic review), book series, book, chapter in book, conference proceeding
Language	English , Malay	Non-english
Time line	Between 2015-2020	<2015
Indexes	Social Science Citation Index, Emerging Sources Citation Index, Art and Humanities Index (Web of Science)	Science Citation Indexed Expanded
Research content	Implementation of pedagogical agent and its relation on learner's cognitive load	Unrelated content on Pedagogical agents

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Next stage is screening. During the identification process, total of 40 papers have been identified from both databases. 12 duplicated articles were removed from the list and result to total of 28 papers were left to be assessed for eligibility. During the eligibility process, full article will be read and reviewed to analyze the content and criteria. During this process, 11 articles were excluded from list as they did not meet the content required for the review which is application of pedagogical agent and its effect on learner's cognitive load. Thus, the remaining17 articles that was used for the review and the data analyze using qualitative means.

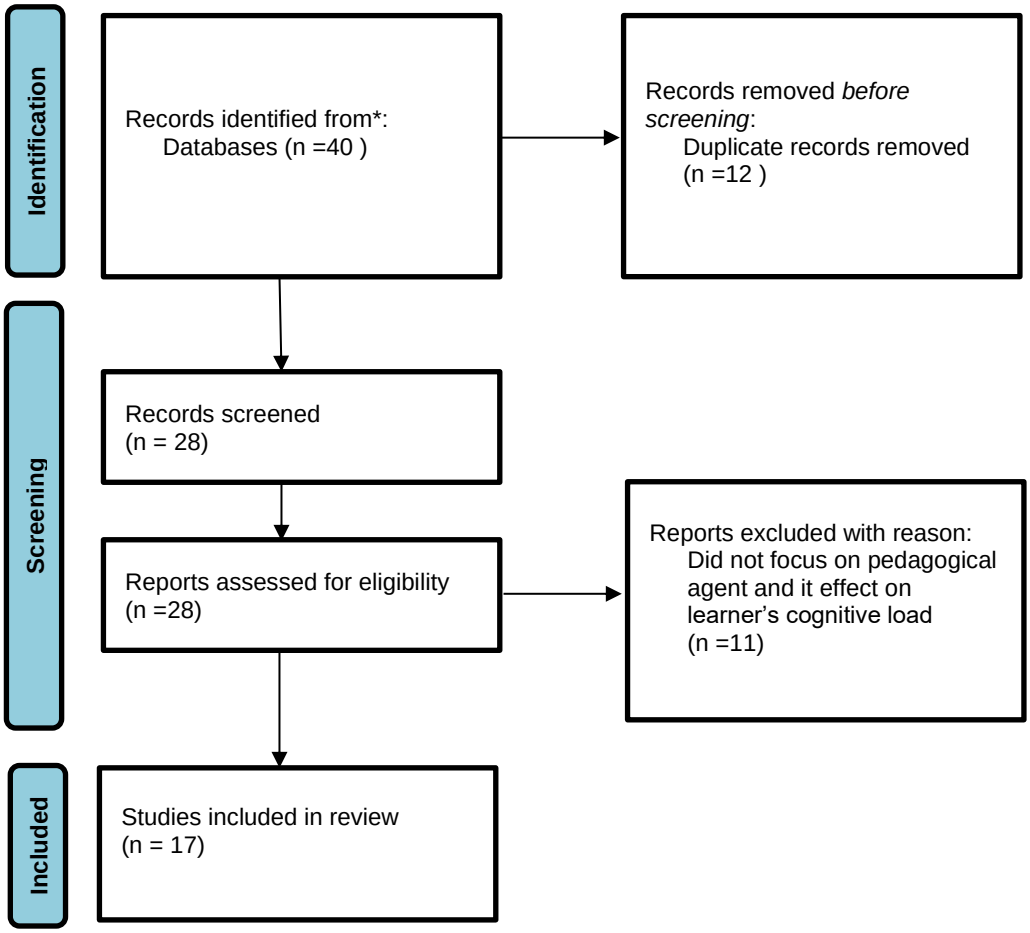

Figure 1. Screening Flow

3.3.3 Data Abstraction and analysis

Remaining articles that have passed the extrusion criteria were assessed and analyzed. Efforts focus on the paper that respond to the research questions posed before. The data required were extracted by going through the abstract first (to understand the whole content of the paper), followed by the full paper to synthesis required data for the review which is pedagogical agent's element tested and its effect on the learner's cognitive load. Qualitative approaches were taken in analyzing the data via content analysis to identify themes related to pedagogical agent design. The authors the organized the data into related sub-themes in accordance with the themes established.

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Table 4. Thematic Analyses

No	Studies	Element involved	Findings on learner cognitive load
1.	Park (2015)	Social Cues (human voices)	pedagogical agent delivering human voice narration to increase the effectiveness of the multimedia design principles using social cues
2.	Yung and Paas (2015)	Cueing	No significant cognitive load
3.	Dinçer and Doğanay (2017)	Multimedia principles	Good multimedia principle design affect cognitive load positively
4.	Liew, Zin, and Sahari (2017)	Social cues(enthusiastic agent)	No significance cognitive load. Enthusiastic agent group better cognitive load.
5.	Schroeder (2017)	Signal and gestures	No significance cognitive load
6.	Lin, Ginns, Wang, and Zhang (2020)	Social cues(conversational speech)	No significance cognitive load But agent with conversional style appeal more to the student
7.	Davis, Vincent, and Park (2019)	Social cues (voice)	No significant but again, slightly better(lower extraneous load)
8.	Schroeder, Chin, and Craig (2020)	Pacing (learner control)	Less mental effort (low cognitive load)
9.	Li, Wang, Mayer, and Liu (2019)	Deictic gestures	No significant. Slightly better
10.	Beege, Schneider, Nebel, Mittangk, and Rey (2017)	Stereotypes (ageism)	No significant
11.	A. M. Johnson, Ozogul, and Reisslein (2015)	Visual signalling	No significant
12.	Moon and Ryu (2020)	Social cue	Significant effect. Better cognitive load with social cues
13.	Arslan-Ari (2018)	Cue and prior knowledge	No significant effect on both variables
14.	Craig and Schroeder (2017)	Types of voices	No significant different, however modern voice engine shows better result compared to human voice and classic voice engine
15.	De Melo, Kim, Norouzi, Bruder, and Welch (2020)	Embodied assistant vs voice only	Embodied assistants yield lower cognitive load
16.	Huang and Mayer (2016)	Anxiety coping strategy	No significant impact
17	Tan, Liew, and Gan (2020)	Message framing	No significant effect

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4.0 RESULTS

The review resulted in three main themes and eight sub themes related to the pedagogical agent elements and its impact on learner's cognitive load. The three main themes are Multimedia principles (three sub-themes), Social Cues (four sub-themes) and Visual design (one sub-themes). The result provided a comprehensive analysis on pedagogical agent's element and its impact on learner's cognitive load.

A total of seven studies focus on pedagogical implementation towards participants in United States of America(USA), two studies focus on pedagogical implementation towards participants in China, two studies focus on pedagogical implementation towards participants in South Korea, one studies focus on pedagogical implementation towards participants in Taiwan, one studies focus on pedagogical implementation towards participants in Turkey and one studies focus on pedagogical implementation towards participants in Malaysia.

Regarding the years of the article been published, five articles was published in 2020, two articles was published in 2019, one articles was published in 2018, five articles was published in 2017, one articles was published in 2016 and three articles was published in 2015.

4.1 Pedagogical Agent Element of Design

This section concentrates on the pedagogical agent element of design that have been used in the studies and its impact on the learner's cognitive load such as multimedia design principles, social cues, and visual design.

4.1.1 Multimedia Design Principles

Based on the review, five out of 17 articles studied on multimedia design elements that was applied onto pedagogical agent design and its impact towards the learner's cognitive load. Initiative in reducing cognitive load throughout multimedia learning has been a buzzword among the multimedia learning designer. Thus, they are several guidelines and suggestion has been given from the researcher in the fields on how to reduce cognitive load in multimedia learning(i.e.,Mayer & Moreno, 2003) . Those guidelines may also be applicable to pedagogical agent design as it still can be categorized as part of multimedia learning. Multimedia design principles that have been investigated are by using pacing in the pedagogical agent design, adding cue, motivation, anxiety coping strategy and message framing. Study by Schroeder et al. (2020), shows that by adding pacing and give learner control over the pedagogical agent, helps in reducing the learner's cognitive load. Another study by Dinçer and Doğanay (2017) also shows that pedagogical agent made up with good multimedia principles give a positive result towards learner's cognitive load. However, the rest of studies that use other design principles such as adding cue(Arslan ‐ Ari, 2018), anxiety coping strategy(Huang & Mayer, 2016) and message framing (Tan et al., 2020) shows no significant impact on learner's cognitive load.

4.1.2 Social Cues

11 out of 17 articles studied on Social Cues in Pedagogical Agent and its impact towards learner's cognitive load. Social cues derived from Social Agency Theory that was proposed by Mayer, Sobko, and Mautone (2003). Social cues originally were tested using types of voice as social cues, however

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there is no clear indicator on what can be listed out as social cues. Based on the research by other researcher on the field, social cues can be categorized as cues that interact socially with the learners. Thus, based from the review, there are several types of social cues that have been used namely; type of voices (i.e.;Craig & Schroeder, 2017; Davis et al., 2019; De Melo et al., 2020; Park, 2015), Deictic gestures (i.e.;Li et al., 2019; Schroeder, 2017; Yung & Paas, 2015), visual cue (i.e.;A. M. Johnson et al., 2015; Moon & Ryu, 2020) and type of speech (i.e.;Liew et al., 2017; Lin et al., 2020).

Based on the evidence, Type of voices used in pedagogical agent did not give significant impact on learner's cognitive load, however it types of voices used may slightly improve learner's cognitive load. Two out of four research that study on voice shows that using human voice slightly improve learner's cognitive load compared to voice that are made using computer. One of the articles also suggested that using modern voice engine yield better result towards learner's cognitive load compared to classic voice engine. Three out of three articles on deictic gestures shows that there is no significant impact on learner's cognitive load. Types of speech also shows no significant impact on learner's cognitive load. One out of two articles on visual signaling indicate that visual signaling yield positive cognitive load towards learner and another article indicate that there is no significant impact on learner's cognitive load.

4.1.3 Visual Design

Only one out of 17 articles reviewed, studied on visual appearances of pedagogical agent. This article studied on ageism of the agent used and the result shows no significant impact on learner's cognitive load.

5.0 DISCUSSION

This study has attempted to systematically analyze the existing literature on pedagogical agent's element and its relation to the learner's cognitive load. Pedagogical agent is a medium used in e-learning to deliver learning to the learners. Among the biggest worried of the implementation of pedagogical agent in learning is that it may cause cognitive overload towards learner. A rigorous review from two main online databases have resulted in 17 article related to pedagogical agent and its impact towards the learner's cognitive load. The result indicates the element of pedagogical agent design and its impact on the learner's cognitive load. Within the scope of this review, three themes and eight sub-themes emerged. Multimedia principles, social cues and visual design are the three main elements used to develop an agent and have been studied its impact towards the learner's cognitive load.

Despite that claim made on cognitive load that it may hinder learning by causing cognitive overload towards learner, there are still few research made to investigate and identify pedagogical element that may cause cognitive overload towards learner. Among the article reviewed, the most element that have been studied is social cues. Social cues have always been a popular element in pedagogical agent making as the pedagogical agent itself often primed with Social Agency Theory that led to the implementation of social cues in pedagogical agent design. Although there is no specific indicator to define types of social cues, researcher understand firmly the concept of social cues and manage to came up with several types of social cues to be implemented with pedagogical agent design. Types of voice used as social cues may influence the effectiveness of pedagogical agent and may impose different kind of cognitive load towards learner. Thus voice that can build good rapport with the learner's work more effective and give better result.

Five out of 17 articles focuses on multimedia principles and its relation to the learner's cognitive load. It is no doubt that good multimedia principles can led to more effective learning design, not only on pedagogical agent but other multimedia learning content. Therefore, the review shows that

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implementation of good multimedia principles onto pedagogical agent yield positive impact on the learner's cognitive load. However, there are several multimedia principles as suggested by Mayer and Moreno (2003) was not tested in pedagogical agent studies.

6.0 FUTURE DIRECTION

There remains much that is unknown about pedagogical agent principles that impose cognitive overload towards learner. As mentioned previously, majority of the paper studied, are focusing on implementation of social cues on pedagogical agent and its impact on learner's cognitive load. Only five papers focus on multimedia design principle on pedagogical agent. Future studies should consider more on exploring various multimedia principles that contribute to the creation of pedagogical agent for multimedia learning. From the finding, good implementation of multimedia principles yield positive impact towards learner's cognitive load since pedagogical agent is consider multimedia tools for learning. However, empirical studies on multimedia design theories and principles that suits pedagogical agent are still low in numbers. Discovering more in this area might leads to more information on better pedagogical agent design.

PRISMA (a standard systematic review guidelines) has been used in this review to rule out necessary information for the research. Based on it this research manages to extract necessary principles and elements used in designing pedagogical agent for multimedia learning. The information on proper principles and elements in designing pedagogical agent are normally lingering around social agency theory and there are still few guidelines provided in designing pedagogical agent (e.g.;Baylor, 2005; Domagk, 2010). Future studies should focus more on the elements and principles in developing pedagogical agent and suggests guidelines in developing one.

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