

# Cognitive Load in Pedagogical Agent Research

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## Abstract

Research on pedagogical agents dates back to the 1970s. Since that time, researchers in the field have expressed conflicting opinions regarding its use in multimedia learning. One of the arguments is that it will result in cognitive overload for students. This systematic review, guided by the PRISMA statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses) was conducted on 17 studies on pedagogical agent and its effect on the cognitive load of learners. The review has resulted to two main themes identified on cognitive load impact towards learner, in learning using pedagogical agent. Several suggestions were given for future studies as to study more in measurement tools used in measuring cognitive load in pedagogical agent studies and pedagogical agent elements that might influence the learner's cognitive load during learning.

**Key Words:** Pedagogical Agent, Cognitive load, Systematic Review

## 1. Introduction

Virtual character that exists virtually in the learning environment and acts as a tutor to mediate during the learning process is called a pedagogical agent. The terminology used to depict Pedagogical Agent might vary among the researcher in the field. Haake (2009) depict pedagogical agent as intelligence agent with educational agendas while other researcher such as Martha and Santoso (2019) describe pedagogical agent as anthropomorphic virtual characters. Its depiction and form are subject to change but the delivery of educational agenda throughout the learning process is still its primary goal. It is possible to date the beginning of research on pedagogical agents to the 1970s, when it began as research on intelligent tutoring systems (Gulz & Haake, 2006). Over the time, the advancement of technology and research direction has made it evolved and equipped with newly added features that made it become what we called today as Pedagogical Agent (Johnson, Shaw, & Ganeshan, 1998). Its existence has been pushed to become more than a mere learning instructor but with more roles such as tutor, friends and companion during the learning process (Johnson & Lester, 2018). It can be assert that Pedagogical Agent play an

important role in delivering learning narrative towards learner.

Despite its ability and features to mediate and facilitate learning, intervention of pedagogical agent does not, however, ensure a significance improvement in learning every single time. Some researcher in the field, have a different opinion on implementation of pedagogical agent in learning where it might cause detrimental impact on learning. A prominent argument was that it could raise the cognitive load on learners (Clark & Choi, 2007).

Cognitive overload towards learner seems to be the biggest drawback in pedagogical agent research. Key factor that influence the learners cognitive load upon intervention of pedagogical agent is the relationship among the learner's attention and pedagogical agent itself (Dinçer & Doğanay, 2017). The splitting attention effect cause by pedagogical agent is what contribute to excessive load towards learners cognitive. The argument of its prolong as each researchers provide different perspective and overview. However, research on the relation between cognitive load and intervention of pedagogical agent remain limited and scarce (Dinçer & Doğanay, 2017; Yusoff, Yusof, & Jamaludin, 2022).

In this study, we will examine research paper that studied the impact of learner's cognitive load upon intervention of

pedagogical agent. The result of those paper will be compared to investigate based on the research question- **Does pedagogical agent cause cognitive overload towards learner?** The focus of the study is to identify whether Pedagogical Agent will cause cognitive overload towards learner using PRISMA statement (Preferred Reporting Items Systematic Reviews and Meta-Analysis).

## 2. Methodology

### 2.1 PRISMA

Research paper that was used in this paper was identified using PRISMA guidelines. PRISMA was commonly used in meta analytic review and analysis has become the most cited method used in systematic review research paper (Sarkis-Onofre, Catalá-López, Aromataris, & Lockwood, 2021).

### 2.2 Resources

This research identified research paper via two main journal databases namely Scopus and Web of science. These two databases were included in this research as it seems as the most comprehensive databases that suite the research areas for this research(Singh, Singh, Karmakar, Leta, & Mayr, 2021).

### 2.3 Systematic Review Process

The review process will follow the same flow as depicted in Figure 1. In the beginning, appropriate research paper will be identify using keywords in the databases search engine. Appropriate keywords were identified from the past research on cognitive load and pedagogical agent.

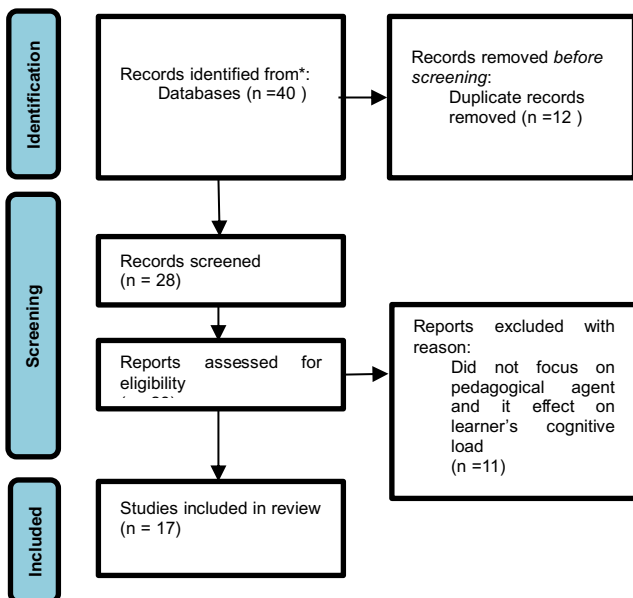


Fig. 1. Screening Flow.

Next is the screening phase. During the identification phase, a total of 40 documents from both databases were identified. Twelve duplicate articles were eliminated from the list, leaving 28 papers to be evaluated for eligibility (Table 1). During the eligibility procedure, the entire article will be read and evaluated in order to assess its content and criteria. Eleven articles were removed from the list because they lacked the needed criterions for the review, which was the use of pedagogical agents and their effect on the cognitive load of learners. The remaining 17 research paper were carried forward for the review and the data analyzed qualitatively. Content analysis were conducted to those 17 papers to identify themes needed for this research as aligned with the research questions. Cognitive load of the student and approach used to measure the cognitive load were then identified and organized accordingly.

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

Table 1. Eligibility and exclusions criterions.

## 3. Findings

Based on the research papers collected, result on learner's cognitive load upon intervention of Pedagogical agent were extracted and identified (Table 2.). Two main themes has been identified on the impact of pedagogical agent towards cognitive load which are; 1) No significant impact and 2) Reduce cognitive load (improve learning).

No	Studies	Cognitive load measure	Findings on learner cognitive load
1.	Park (2015)	Paas Self-rating scale(9 point likert)	Reduce cognitive load
2.	Yung and Paas (2015)	Paas Self-rating scale	No significant cognitive load
3.	Dinçer and Doğanay (2017)	Self-rating scale adopted by Paas	Good multimedia principle design affect cognitive load positively
4.	Liew, Zin, and Sahari (2017)	7 point likert scale	No significance cognitive load.
5.	Schroeder (2017)	Paas Self-rating scale	No significance cognitive load
6.	Lin, Ginns, Wang, and Zhang (2020)	7 point likert based on Paas(1992) and Krell(1997) (3 items)	No significance cognitive load But agent with conversational style appeal more to the student
7.	Davis, Vincent, and Park (2019)	10 pint likert scale, (10 items)	No significant but again, slightly better(lower extraneous load)
8.	Schroeder, Chin, and Craig (2020)	Paas Self-rating scale	Less mental effort (low cognitive load)
9.	Li, Wang, Mayer, and Liu (2019)	9-point likert(4 items)	No significant. Slightly better
10.	Beege, Schneider, Nebel, Mittangk, and Rey (2017)	9 point likert from Eysing,de Jong,Berthold,Koloffel,Opfermann & Wothers (2009)	No significant
11.	Johnson, Ozogul, and Reisslein (2015)	5 point likert (6 items) based on Paas	No significant
12.	Moon and Ryu (2017)	7 point likert (45 items)	Significant effect. Better cognitive load

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13.	Arslan-Ari (2018)	Paas Self-rating scale	native load with social cues No significant effect on both variables
14.	Craig and Schroeder (2017)	Paas Self-rating scale	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)	NASA-TLX scale (21 tick marks)(5% to 100%)	Embodied assistants yield lower cognitive load
16.	Huang and Mayer (2016)	Paas self-rating scale	No significant impact
17	Tan, Liew, and Gan (2020)	9 point likert developed from Lusk and Atkinson(2007)	No significant effect

**Table 2.** Thematic Analyses

Based on the reviewed research papers, no data found that shows that pedagogical agent impose cognitive overload among learners. 12 out of 17 papers show there is no significance different on cognitive load upon intervention of pedagogical and non-agent condition. This indicate that majority numbers of papers showing that no significant difference on learner’s load upon intervening with pedagogical agent during learning.

The rest of paper which is five out of 17 shows positive impact on learner’s cognitive load (lower load) upon intervening with pedagogical agent during learning.

#### 4. Discussion

The initial aim of this study is to investigated the impact of pedagogical agent towards learner’s cognitive load using a systematic review on the past studies. Despite the claim made on pedagogical agent that it may impose cognitive overload towards learner, the review done to prove the claim are still lacking in numbers. Based on the result of this review, it shows that pedagogical agent does not impose cognitive overload towards learner. However, majority of research paper reviewed also shows that there is no significance impact on learner’s cognitive load upon intervention of pedagogical agent. Only five out of 17 research shows positive impact on learner’s cognitive load upon intervention of pedagogical agent. Although pedagogical agent will not impose cognitive overload towards learner, it also shows that its contribution towards learning is not really significance.

However, this may lead towards more possibilities in pedagogical agent research in future. Based on the paper reviewed, we can see that majority of the paper implemented multiple adaptation of of Likert scale as a measurement tools in measuring cognitive load among learners. This might yield different result between pedagogical agent studies. Thus, future research should focus on the appropriate cognitive load measurement in pedagogical agent studies.

This review only focusses on the general pedagogical agent research and its impact on learner’s cognitive load. Pedagogical agent is normally included with several attributes and elements that will add more value towards

learning and will differentiate between one pedagogical agent and another. These elements and attributes might influence the outcome of the pedagogical agent performance towards learning and learner’s cognitive load. Further studies on these elements and attributes and its relation towards learner’s cognitive load might optimize the capability of the pedagogical agent in learning.

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