

# Adaptive Learning in Computing Education: A Systematic Mapping Study

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**Abstract.** Adaptive learning has become popular among researches in the recent decade. It is believed in giving good benefits which promotes effective ways or methods to improve youth performance in education either for computing field or any non-computing fields. This study focuses on investigating the contribution of adaptive learning in computing education including the adaptation environment involved. This systematic mapping study was undertaken to analyse all relevant and related studies. A set of three research questions were defined in which 68 primary studies, dated from 2012-2020, were analysed and evaluated. The mapping shows the trends and the taxonomy of the contribution adaptive learning in computing education. However, the result also can be applied for non-computing education field. Most of the studied areas are on providing adaptive learning environment and investigating the suitability of learning contents for the youth in teaching and learning. This study summarized the existing research of adaptive learning over past seven years and there is a potential for more research in this area.

## 1. Introduction

In the recent decades, computing education has become a fundamental course in learning institute [1]. It is an integral part of the STEM process that infuses all disciplines with critical thinking and problem-solving skills. Thus, many researchers investigate the challenges and solutions for teaching and learning computing while making efforts in helping world to meet the demands. Adaptive learning (AL) has been an attractive topic in education field for many years as methodologies and strategies in improving the effectiveness and performance through teaching and learning. AL can be defined as a form of training which specific instructional methods resources are used to meet the specific learning needs of individuals [2]. Adaptiveness is important in the process of learning [3]. Different learners have different type of learning. Due to this believe, researchers provide a variety of AL environment that is based on the adaptive features such as learner preferences which are imperative to be considered in designing and providing good methodologies. Although this study is focusing on the computing fields, however, the findings shows that this mapping study generally can provide adaptation in teaching and learning on non-computing education as well. This paper is presented as follows: The related work is summarized in Section 2. Section 3 explained the approach used in this study. The findings of the study are presented in Section 4 and the conclusion in Section 5. Section 6 presented the future work.



## 2. Related Works

The literature on adaptive provides existing studies and there are many references that can support as a good pre-presentation for this mapping study which done by [4], [5] and [6]. [4] present a systematic mapping study that focus on the adaptation content in robotic systems. The study has analysed 15 selected papers from 137 papers resulted from available online databases dated up to 2017. Basically, the study is aimed to show the trends on using robotics environments as a pedagogical activity for learners in teaching and learning. While in the previous work [5], the authors discuss on the adaptive learning environment through self-directed study that provides with personalized information. By analysing 78 research papers dated form 2010-2017, they presented various personal traits and reviewed their identification techniques for guidance in developing adaptive learning system.

Other than that, [6] has reviewed and analysed the trends and development of adaptive learning in the recent decade. The authors investigate many issues in 45 relevant journals throughout the years of 2007 to 2017 based on selective parameters which includes the learning support, subject involved and many more. The finding shows that AL has the potential to be applied into development of smart devices. The study done by [4], [5] and [6] were not specifically focus on the trends and contribution of adaptation environment in computing education. However, these three mapping studies can be regarded as a good source of information to this study. We have therefore identified several other important research areas under AL.

## 3. Research Method

This systematic mapping study (SMS) paper applied the similar methodology as a systematic literature review (SLR) which follows the guidelines constructed by [7] and [8]. These guidelines are widely used in conducting SMSs and SLRs. There are five process for completing this study which are; (1) problem formulation which defined as research questions that is based on the stated objectives of the study, (2) the search strategy which can be defined by identifying the keywords on relevant online databases provided by the search engine, (3) the article selection based on the inclusion and exclusion criteria, (4) the extraction of attribute and relevant formation in order to map in a systematic classification, (5) the synthesis of data and result reported.

### 3.1 Research Question

The main objective of the study is to investigate the trends of adaptive learning contribution specifically in teaching and learning computing. Taking into account the aims of this review, research questions are formulated to meet the goal. It is necessary in order to adequately address the wider scope of this study. The research questions are as follows; **RQ1**. What is the taxonomy of AL in computing education? and **RQ2**. What are the techniques applied in adaptive learning?

#### 3.1.1. Search Procedure.

Search strings are altered by following the requires format by each online database. A total of five electronic databases is used to extract the relevance information regarding the study. Table 1 shows the search engine and the number of papers for each of the five databases while Table 2 shows the search strings.

**Table 1.** Research Questions and Motivation of Study.  
Number of Papers by Search Engines

Search Engine	Number of Papers
IEEEExplore	19
SpringerLink	14
ACMDigital Library	15
ScienceDirect	14
Google Scholar	6
<b>Total</b>	<b>68</b>

**Table 2.** List of Search String

Search Query
“Adaptation”, “Adaptive Learning”, <b>AND</b> “Computing Education”, “Computer Science”, “Programming” <b>OR</b> “Artificial Intelligence”

Systematic searching is conducted to identify relevant studies based on the research questions. This study applied inclusion and exclusion criteria in filtering the papers. The criteria are as follows: (1) the paper is reported in English/Bahasa Malaysia language, (2) the full text description of the paper is available, (3) the paper should include the area of the study and (4) the year range of paper must be 7-5 years back from present year. Originally, this study has collected 413 studies from the selected online databases based on the search query as shown in Table 2. After the inclusion and exclusion are applied as mentioned, 68 papers are resulted as the relevant selected studies for this research. Figure 1 shows the complete search process.

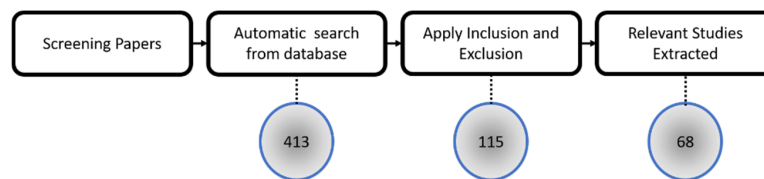


Figure 1. Stage of Search Selection

#### 4. Research Result

This section presents the results obtained from the research contribution based on the research question. Figure 2 shows the taxonomy of AL resulted based on the existing selected studies to answer **RQ1** (“**What is the taxonomy of Adaptive Learning in Computing Education?**”). The research question aims to investigate the trends of AL in which environments and adaptive features commonly involve in developing AL. Originally, the taxonomy is aimed to focus on the computing field. However, based on the analysis of AL, the result shows that, AL also can be used in any other field of non-computing education. This study mapped the adaptation environments and adaptive features throughout the years as shown in Figure 3 based on the developed taxonomy. Adaptation environments are the subject of adaptation while adaptive features can be described as personal traits that underlie the characteristics of learning model such as learning and cognitive styles [5]. Based on the analysis, adaptive learning was most adapted on learning platform, content and learning environment based on adaptive features. Learning styles, learning environment and learning contents are shown as the most adaptive features that is commonly used for adaptive learning. For instance, based on Figure 3, throughout the year 2012 to 2020, in total 24 of selected studies out of 68 applied adaptive learning techniques on learning platform which is based on selected adaptive features included the learning style and level of knowledge.

The next research question is aimed to study what techniques are applied for adaptive learning. In addition, the supporting tool and the learning theories that have been used for adaptive learning also need to be investigated. Thus, by answering the **RQ2** (“**What are the techniques/methods applied in adaptive learning?**”), Figure 4 depicts the contribution graph of technique that is used by the existing studies of AL.

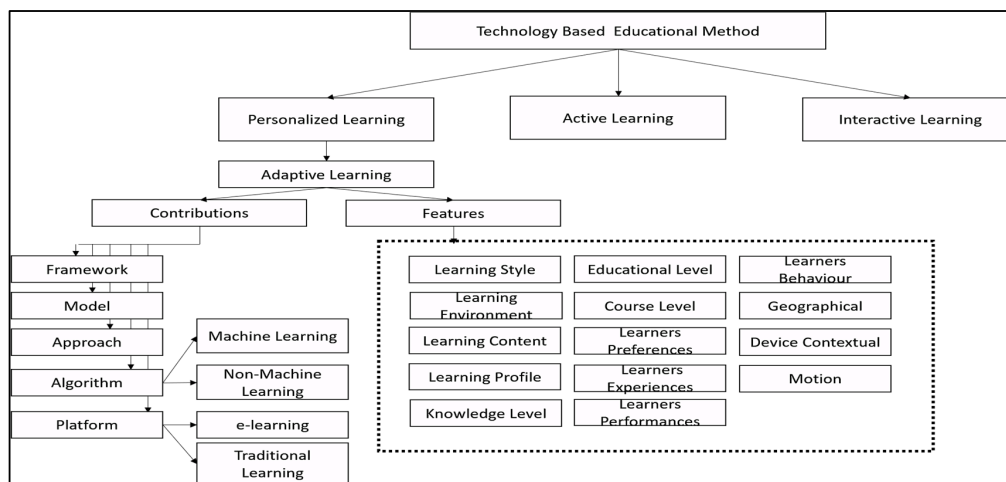
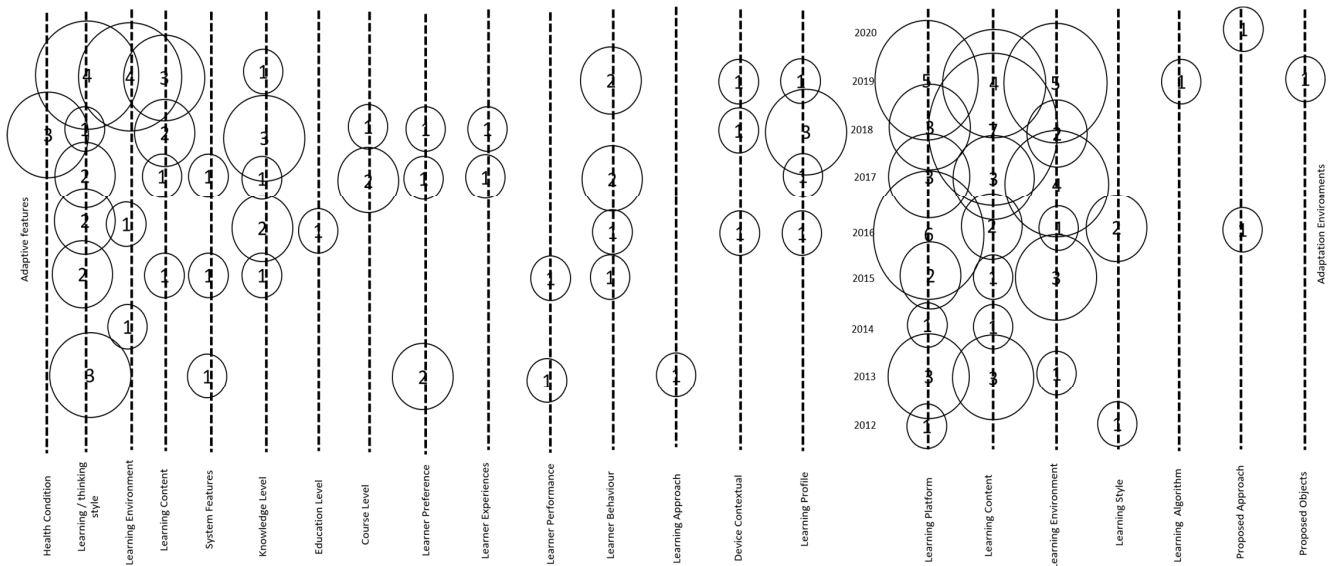
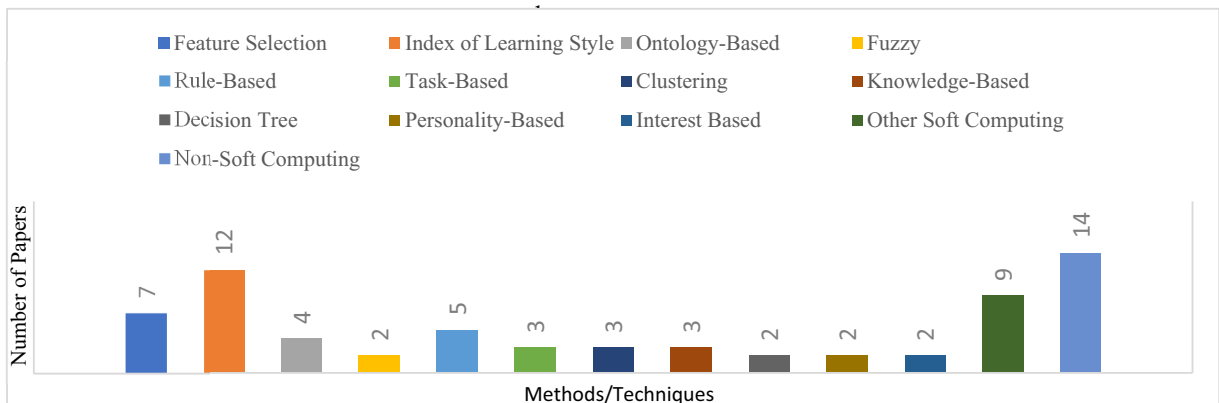


Figure 2. Taxonomy of Adaptive Learning based on Selected Study

The graph plotted at most 2 studies applied same techniques within those years and other studies applied other soft computing and non-soft computing once without specifying the name. Based on the analysis, Index of Learning style method [9] is common techniques used as most of the studies are applying adaptation based on the learning styles. The technique consists of learning theories that are referred by the researchers such as Felderman-Silverman Model [9], VARK Model [10], Bloom Taxonomy [11] and many more. Besides that, feature selection [12] and clustering [13] have been common techniques for applying adaptation based on learning contents and environments.



**Figure 3.** Map of research with respect of adaptive features and adaptation environment throughout



**Figure 4.** Contribution Graph of Techniques and Methods applied for adaptation

**5. Conclusion**

This paper presents an overview of existing research that has applied and investigated on the adaptive learning based systematic mapping study. This study reveals that majority of research is focused on adaptation on learning platform, content and environment based on adaptive features which include learning style, learning profile, learning environment, and learning content. In addition, soft computing and non-soft computing techniques and methods are commonly used to develop adaptive learning which includes feature selection and many more. A further investigation on the most used adaptive either for learning, teaching or both teaching and learning will be performed for future work including the further details of the techniques used.

## 6. Future Work

For future work, this study will analyse the different direction of research in the area of adaptive learning which able to provide discussion on learning.

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