A review on the attainment of Outcome-Based Education Using Educational Data Mining

Yogeswari Suppiah[1], Rajermani Thinakaran[2]
Faculty of Information Technology, INTI International University, 71800 Nilai, Negeri Sembilan, Malaysia[1,2]

Email: yogeswari.suppiah@newinti.edu.my[1], rajermani.thina@newinti.edu.my[2]

Abstract

This paper aims to conduct a review on the attainment of Outcome-Based Education (OBE) using Educational Data Mining (EDM). It analyses the types of assessment, the type of attainment, and the techniques or tools relevant to Outcome-Based Education (OBE). The Preferred Reporting Items for Systematic Reviews (PRISMA) statement was used as a formal systematic review guideline for data collection. Data was obtained from research studies over the period 2015–2020. The analysis included 25 papers from Scopus, Science Direct, IEEE Xplore, Google Scholar databases. Findings indicated that there were varieties of approaches and techniques applied in evaluating OBE attainment using EDM. Besides that, there was a significant increase in the number of researches related to EDM and OBE attainment in recent years. The type of assessment and attainment were evenly distributed and most of the researches used generalized formula for evaluating OBE attainment. Associate Rule Mining and MS Excel were among the most preferred tools used for the research.

Keywords

Outcome Based Education; Educational Data Mining; Program Educational Objectives; Programme Learning Outcomes; Course Learning Outcomes

Introduction

Higher education providers are overwhelmed with huge amounts of information regarding student enrolment, the number of courses completed, and achievement in each course, performance indicators, and other data. This has led to an increasingly complex analysis process of the growing volume of data and to the incapability to make decisions regarding curricula reform and restructuring. On the other side, Educational Data Mining (EDM) is a growing field aiming at discovering knowledge from student's data in order to thoroughly understand the learning process and take appropriate actions to improve the student's performance and the quality of the delivery of the courses (Suhirman, Zain, & Herawan, 2014).

EDM uses data mining techniques to analyse huge amounts of student data in educational environments. The main purpose of EDM is to analyse and solve educational issues and, consequently, improve educational processes. With the emergence of EDM applications in educational environments, several techniques have been identified to implement these applications. These applications aim to help decision-makers in the educational institutions to understand student situations, improve students' performance, identify learning priorities for different groups of students and develop the learning process

(Alshareef et al., 2020; Shah & Choksi, 2019).

Over a decade, numerous studies have been conducted in the field of EDM. Most of the research is concerned with analyzing and studying data from academic databases to better understand the students and the educational settings. The increasing emphasis on data mining in the educational sector has developed a novel emerging research field. It is concerned with the analysis of the educational data that are originated from the educational environments. There exist several data mining approaches that are usually used in EDM such as Classification, Regression, Time Series Analysis, Clustering, Association Rule Mining, and Neural Networks(Islam Rifat, Al Imran, & Badrudduza, 2019).

An OBE (Outcome Based Education) curriculum means clearly focusing and organizing everything in an educational system about what is essential for all students to be able to do successfully at the end of their learning experiences. It also goes on to define and propose the best methodology to help students to learn most effectively within their educational environment. It is clearly stated in the curriculum of the intended teaching outcome and standard. An OBE curriculum is a product model dependent on what learning outcomes are set. The successful implementation of a curriculum depends on the successful interaction of lecturers, students, and the knowledge they share. The curriculum is therefore what is actually happening in the lecture room, in addition, it is a set of documents for implementation by lecturers (Muhamad et al., 2014). The OBE focuses on the student-centered approach to teaching and learning. The main emphasis is given on students' satisfaction level, improving the ability of the student to learn, apply and use the concepts. It precisely describes the difference between aim, objective, and learning outcome (Bhatia, Girdhar & Singh, 2018).

Elements of the OBE curriculum consist of Programme Learning Outcomes (PLO) and Course Learning Outcomes (CLO). Programme Educational Objectives (PEO) is an expression of a long-term purpose that describes the career and professional accomplishments that the program is preparing students to achieve within 3 to 5 years after graduation. PLO describes what graduates of a program should be able to do because of learning experiences within that program. Learning outcomes are concerned with the achievements of the learner rather than the intentions of the lecturer. At the course level, the CLOs are related to certain PLOs to describe the learning outcomes that the students should attain and achieve. Students are expected to be able to perform or attain the CLOs in terms of skills, knowledge, and behavior or attitude after going through the course (Muhamad et al., 2014).

Methodology

A search strategy was developed to identify relevant literature. This search strategy was tailored to four databases: Scopus, Science Direct, IEEE Xplore, Google scholar . The search terms were the following: 'Outcome Based Education' OR "Program Educational Objective" OR "Educational Data Mining". All searches spanned from database inception until 2020, included journal articles, review papers, researches reports, published in English only.

The selection criteria were based on the Preferred Reporting Items for Systematic Reviews (PRISMA) Statement (Moher et al., 2009). PRISMA addresses several conceptual and practical advances in the science of systematic reviews. The search mainly focused on mapping existing literature on EDM in the field of Computer Science. The search then narrowed to the subject area to OBE and PLO, specifically CLO, PLO, and PEO attainment. The search span was from the year 2015 to 2020. All the articles before 2015 were excluded from the search. The articles were extracted not based on any country or region. Most of the articles were extracted from the United States, India, Malaysia, Spain, and China. Actively conducted researches related these top five countries to EDM.

A sum of 3374 articles were recovered in view of the models. A sum of 3156 articles were excluded at this stage. There were 218 records were extricated at this stage. The study is based on only original research articles, review papers, and conference papers. For maintaining the quality of the review, all duplications were checked thoroughly. Abstracts of the articles were checked thoroughly for the analysis and purification of the articles to ensure the quality and relevance of academic literature included in the review process. A careful evaluation of each research paper was carried out at a later stage. After the filtration of duplicates and assessing each article on the aforementioned inclusion and exclusion criteria, only 45 articles were selected.

Figure 1 below shows the literature inclusion and exclusion at every stage. Finally, after checking through each article abstract for quality and relevancy, only 25 articles were extracted. The articles were original articles and conference papers that are relevant to the research topic.
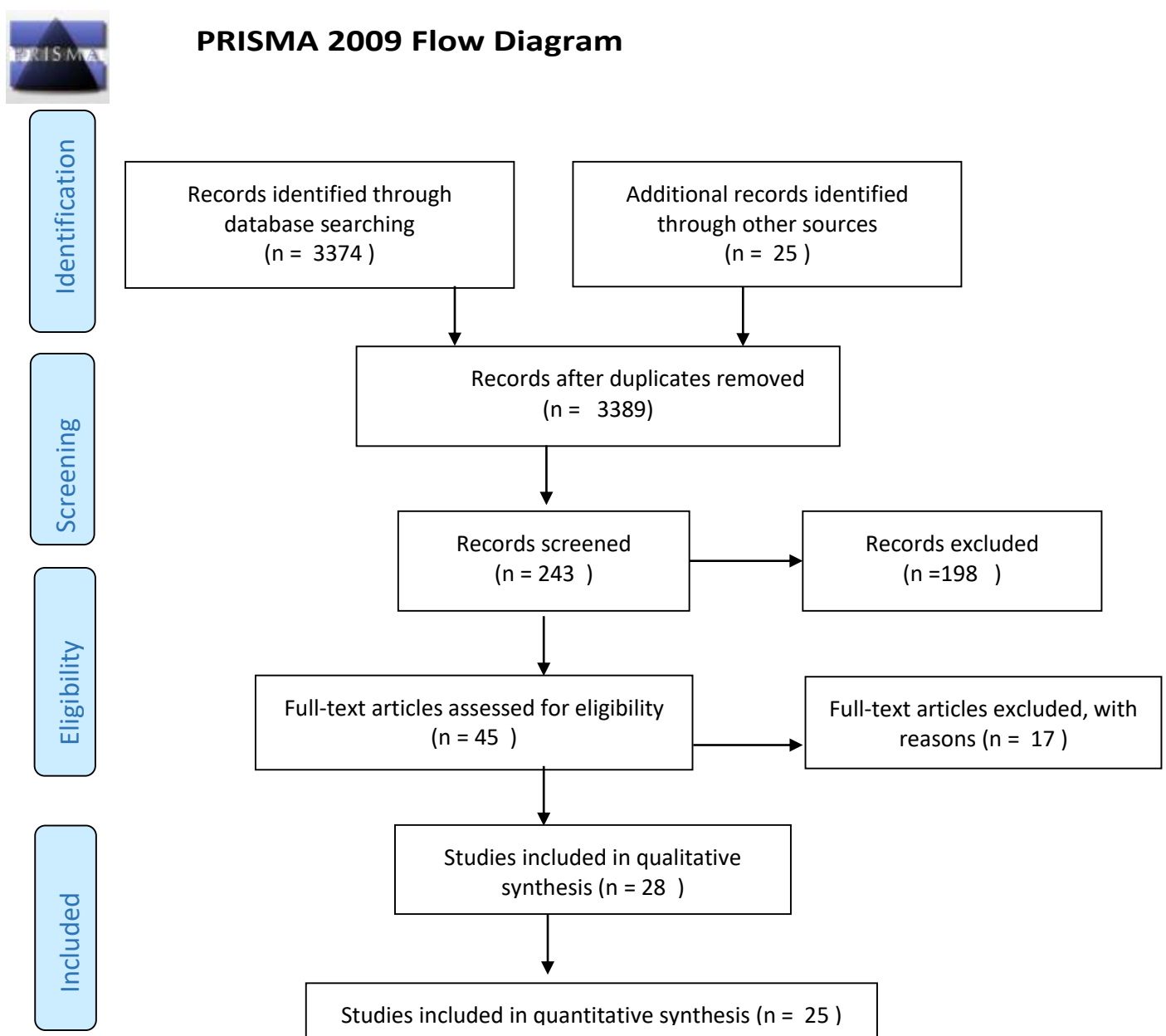
PRISMA 2009 Flow Diagram

Figure 1. Shows the literature inclusion and exclusion at every stage

Results and Discussion

Table 1 shows the different perspectives and approaches implemented in the evaluation of OBE attainment. Some researches were focusing on the CLO attainment only (Ahmad, Ali, & Zainudin, 2011; Sawant, n.d) and the others are focusing on the PLO and PEO attainment separately (Rajak et al.,2019; Hussain Khan, 2019; Mohamed et al., 2019). Some of the research was done based on Direct data such as students' grades only (Yahya & Osman, 2019; Yahya & Mohammed, 2019; Islam Rifat et al., 2019; Wahab et al., 2011; Abdeljaber & Ahmad, 2017). Some of the researchers were based on indirect data such as the Alumni survey. (Hairi et al.,2019; Tshai et al., 2014; Bhatia et al., 2018; Desai et al., 2018; Mohamed et al., 2019). Furthermore, some of the researches are either focusing on direct sources such as students' grades only or fully based indirect sources such as Alumni surveys (Bhatia et al., 2018; Tshai et al., 2014). There were a variety of methods and tools used for evaluating the attainment of PEO such as survey, data mining algorithm, WEKA tool, Rasch Model, PLS-SEM and etc.

| No | Article | Title | Type of Assessment | | Type of attainments evaluated | | | Algorithm/ Technique/ Tool |
			Direct	Indirect	CLO	PLO	PEO	
1	(Hairi et al., 2019)	Identifying instruments to measure programme educational objectives (PEO) achievement in Malaysia		√			√	Indirect data-Survey
2	(Rajak, Kumar Shrivastava, Bhardwaj, & Kumar Tripathi, 2019)	Assessment and Attainment of Program Educational Objectives for Post Graduate Courses	√	√		√	√	Data from Direct and indirect tools analysed using generalised formula
3	(Rajak, Shrivastava, & Shrivastava, 2019)	Automating Outcome Based Education for the Attainment of Course and Program Outcomes	√	√		√	√	Direct assessment tools- Internal & External assessment, Project and Placement. Indirect assessment tools - various surveys like Alumni survey, Exit survey, Curriculum survey and Employer feedback.
4	(Rajak, Shrivastava, & Tripathi, 2019)	An approach to evaluate program outcomes and program educational objectives through direct and indirect assessment tools.	√	√		√	√	Data from Direct and indirect tools analysed using generalised formula
5	(Hussain Khan, 2019)	A Unified Framework for Systematic Evaluation of	√			√	√	Unified framework

		ABET Student Outcomes and Program Educational Objectives.					
6	(Tshai et al., 2014)	Outcome-based education - The assessment of programme educational objectives for an engineering undergraduate degree		√			√	Survey
7	(Yahya & Osman, 2019)	Using Data Mining Techniques to Guide Academic Programs Design and Assessment	√				√	Association Rule Mining Techniques -Apriori Algorithm
8	(Kaur & Girdhar, n.d.)	A Framework For The Indirect Assessment Tool For Outcome Based Education Using Data Mining		√	√	√		Survey conducted to collect data and analysis using WEKA Tool
9	(Yahya & Mohammed, 2019)	A Novel Use of Educational Data Mining to Inform Effective Management of Academic Programs	√				√	Association Rule Mining techniques and Apriori Algorithm used to discover mapping rules and correlation between PEOs and SOs
10	(Ahmad et al., 2011)	An improved course assessment measurement for analyzing learning outcomes performance using Rasch model	√		√			Rasch Model and Winsteps software
11	(Islam Rifat et al., 2019)	Educational Performance Analytics of Undergraduate Business Students	√				√	Classification Algorithm-Gradient Boosted Tree, Random Forest, Tree Ensemble, Decision Tree, SVM and KNN -Data Mining Tool KNIME(Konstanz Information Miner)
12	(Wahab et al., 2011)	Program outcomes measurement and assessment processes. *Procedia - Social and Behavioral Sciences*	√		√	√		Ms.Excel
13	(Abdeljaber & Ahmad, 2017)	Program outcomes assessment method for multi- academic accreditation bodies: Computer science program as a case study	√		√	√		Data from Direct sources analysed using generalised formula to measure CLO and PLO attainment
14	(Bhatia et al., 2018)	An automated survey designing tool for indirect assessment in outcome based		√	√	√		Classification Algorithm and WEKA tool

No	Author	Title						Method
		education using data mining						
15	(Sawant, n.d.)	Course Outcomes Attainment Analysis using Automated Tool - IONCUDOS	√	√	√			Automated Tool-IONCUDOS
16	(Desai et al., 2018)	An approach for evaluating program educational objectives using indirect method		√			√	Indirect data-Survey
17	(Mohamed et al., 2019)	Assessing the Relationship between Program Education Objectives and Program Learning Outcomes in Outcome-Based Education Using Partial Least Squares-Structural Equation Model		√		√	√	PLS-SEM (Smart PLS 3.0)
18	(Subbaraman, Dharmadhikari, & Patil, 2016)	Computing Attainment of Program Outcomes by Associating Credit Based Weight Factor of the Components of Curriculum	√	√	√	√		Direct and indirect assessment. Computations of attainment of using course weightage factor and generalised formula
19	(Rajak, Shrivastava, & Tripathi, 2020)	A comparative study based on OBE for different batches of MCA students	√	√		√	√	PLO and PEO attainment calculated using generalised formula.
20	(Abbadeni, Ghoneim, & AlGhamdi, 2013)	Program Educational Objectives Definition and Assessment for Quality and Accreditation		√			√	PEO attainment calculated using generalised formula.
21	(Raghunathan, 2013)	Outcome Based Education: A Case Base Approach	√	√	√	√		CLO and PLO attainment calculated using generalised formula.
22	(Terang, Bisoyi, & Chandna, 2016)	Weightage factor analysis between Programme Outcomes and Course Outcomes: A case study	√			√	√	CLO and PLO attainment analysis done based on internal tests using Excel.
23	(Roy, Varshney, & Chandna, 2016)	Learning through Modern Tools in Power Quality to Evaluate Course Outcome	√			√	√	CLO and PLO attainment calculated using generalised formula based on direct data.

Table 1.   Type of assessment and PEO attainment evaluation

Based on the analysis, the author found that the outcome of the research tends to be incomplete and lacks some details required. Hence, a more comprehensive and detailed study is required for further analysis in the future towards the best tool to use for evaluating OBE attainment.

Figure 2 shows the frequency of publication based on search terms: 'Outcome Based Education' OR "Program Educational Objective" OR "Educational Data Mining" for years spanning from 2015 till 2020. The results show a relevant increase in the number of published studies in recent years.
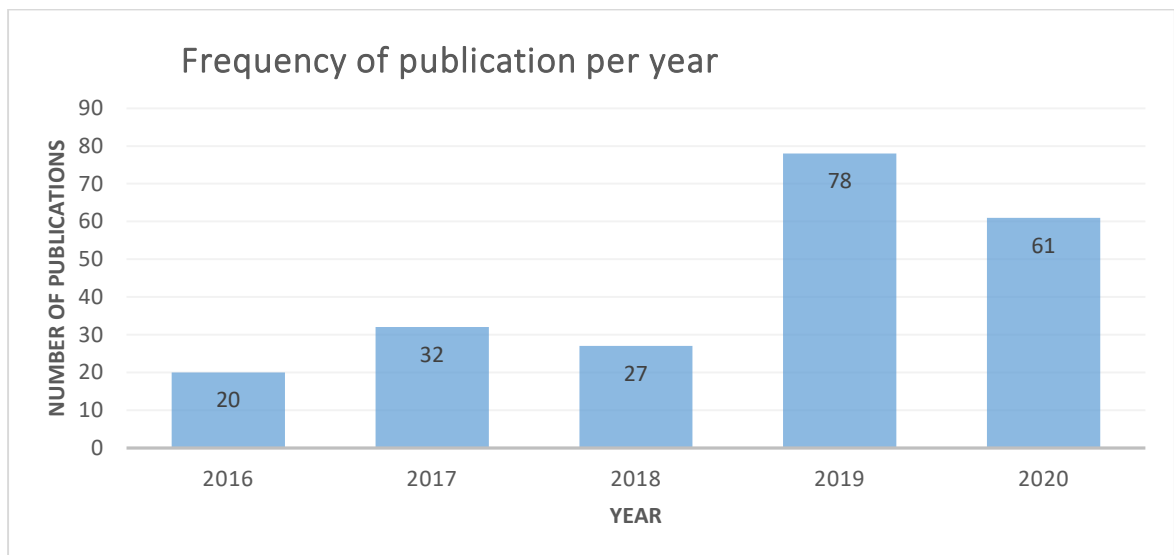

Figure 2. Frequency of publication distribution from year 2016-2020

Figure 3 shows the type of assessment and attainment. The two types of assessment are direct and indirect. Direct assessment based on the test, assignment, and project results. On the other side, indirect assessment is based on the alumni survey, employer survey and etc. The attainment of OBE is based on CLO, PLO, and PEO attainment.
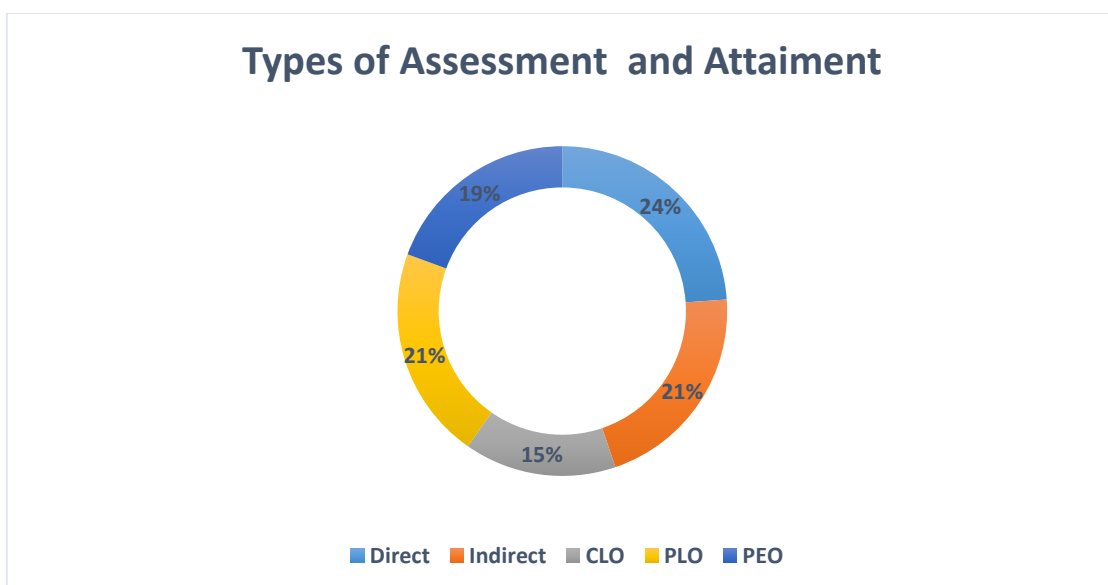

Figure 3: Distribution of Assessment and Attainment types

Figure 4 shows the algorithm, tools, and techniques applied in evaluating OBE attainment. The majority of the researchers used generalized formulas. Associate Rule Mining was the most popular technique and Microsoft Excel was the common tool used.
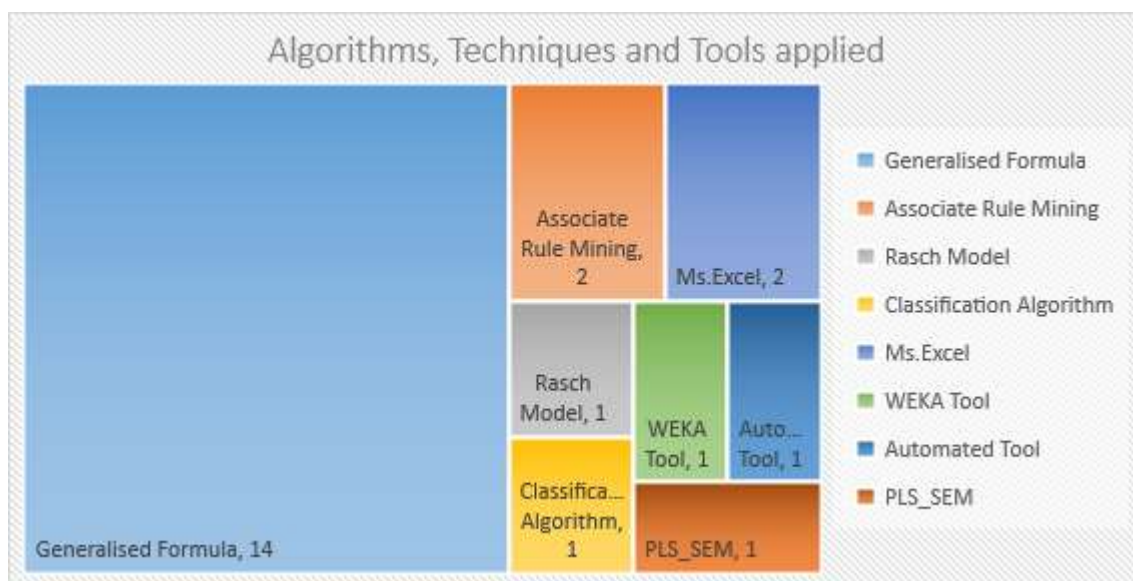

Figure 4: Algorithm, Techniques and Tools applied

Conclusion

This paper aims to develop a systematic review on the attainment of OBE using EDM. The paper highlights the types of assessment, the type of attainment, and techniques relevant to OBE attainment. Findings indicate that there was a variety of methods and approaches used for evaluating OBE using EDM techniques. Besides that, there was a significant increase in the number of researches related to EDM and OBE attainment in recent years. The type of assessment and attainment were evenly distributed. Most of the researches used generalized formula for evaluating OBE attainment. Associate Rule Mining and Microsoft Excel were among the popular tools used for the research. A more comprehensive and detailed study is required for further analysis in the future. The available Data Mining tools need to be explored further to identify the best tool to produce the best outcome of the research. Subsequently, it tends to be utilized and applied in the current school system to assess the OBE attainment which is vital for Continuous Quality Improvement(CQI) as featured and accentuated by the government.

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