Effects of Big Data Analytics in Learning Management Systems for Improving Learners' Academic Success

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Recommended Citation:

Abdellah Ibrahim Mohammed Elfeky; Ali Hassan Najmi; Marwa Yasien Helmy Elbyaly (2024) "Effects of Big Data Analytics in Learning Management Systems for Improving Learners' Academic Success" *Profesional de la información*, v. 33, n. 1, e330016.

https://doi.org/10.3145/epi.2024.0016

Manuscript received on 6th May 2023
Accepted on 4th October 2023

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Abstract

In education, big data utilization has offered significant opportunities to support students in the era of e-learning platforms. The present research investigated the impact of big data utilization on learning management systems (LMSs) in the context of developing students' academic success. The sample consisted of 120 students of the third level of the Department of Education and Psychology in Najran University, Saudi Arabia. Participants were divided into two equal experimental groups, The first experimental group learnt through using reports derived from big data analysis while studying "Research Methods" course via Blackboard; while the second experimental group studied the same course via Blackboard only, without any data analytics intervention. An achievement test, at the end of the course, was administered on both groups to assess the level of academic success. Findings revealed that integration of big data reports as intervention via Blackboard significantly enhanced learner's academic success.

Keywords

Big Data, Blackboard, Learning Management Systems, LMS, Academic Success.

1. Introduction

Most eLearning platforms cater to harnessing the power of Big Data to learn more about learners' behavior, preferences, and performance (**Oguntimilehin; Ademola**, 2014). Big data-driven decisions help personalizing the learning experience and identifying areas of improvement, as teachers can track learners' progress and performance. The eLearning platforms, including Blackboard, have the potential to optimize courses after analyzing data on learners' engagement and satisfaction. This enables them to identify course modules and develop new content aligned with learners' interests (**Tulasi**, 2013; **Mukherjee; Shaw**, 2016). The big data utilization also improves online learning environments and reveal risk indicators linked to student's involvement in the learning process (**Daniel**, 2019). In addition, utilization of big data technology aims to accurately analyze data, enhance creative online learning, and draw conclusions in order to derive insightful knowledge (**Javed; Zeadally; Hamida**, 2019).

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Big data implies any system that handles significant volumes of data, such as video, text, and audio). In addition, big data can be defined as essential tools used to extract valuable conclusions from data (**Kühn *et al.***, 2018; **Rahmani *et al.***, 2021; **Javed *et al.***, 2019). Big Data depends upon the availability of vast learner data, including the learner's behavior within LMSs. Higher education institutions can benefit from big data to address various educational challenges, such as the consistency in learner's success and control the dropout rate. In other words, it is important to transfer from focusing solely on the average student to individualized attention based on students' interaction data in the digital environment (**Saeed; Al Aghbari; Alsharidah**, 2020; **Aguilar**, 2018). Technology of big data analysis may maximize the benefits of learning management systems (LMSs) and, in the same time, enhance the learning experience by making timely data-driven decisions (**Binsawad; Abbasi; Sohaib**, 2022; **Cantabella *et al.***, 2019). Consequently, the learner's behavior in LMS will generate vast data, which can aid academic decision-making process and impact the learners' academic motivation and learning styles (**Aguilar**, 2018).

A lot of studies have been conducted that have established the usefulness of Big data analytics in the conduct of LMSs and exploitation of technology for learning management; and how to use big data analysis techniques to enhance learning outcomes (**Huda *et al.***, 2018). However, there is scant information available on the effects of big data in LMSs for academic success development or enhancing the learners' academic capabilities to predict success. There remains a scarcity of research regarding the effect of effective utilization of this technique for planning and strategizing learner's academic achievement (**Shorfuzzaman *et al.***, 2019). Besides, big data analytics generated from learner interactions in LMSs namely video interaction events have are still in need for more attention.

The current study aimed to fill this gap by investigating the impact of big data utilization on learning management systems (LMSs) in the context of Najran university students using the blackboard LMS. The experiment comprised an achievement test as a study tool to examine this impact of big data on the academic performance of the students using Blackboard system. The study collected data from the students of the Najran university, Saudi Arabia, who used the Blackboard LMS for all their study needs. The data was categorized, examined and saved in nine-reports using big data analytics techniques, which were integrated as intelligent tools into Blackboard during the teaching of an advanced course, Research Methods. These reports were accurately analyzed to assess how relevant they were to the main objectives of the present study. Among the selected reports was the "Student Overview of an Individual Course", which provided detailed statistics on video interaction events, i.e. learners' interactions with video lectures organized by date. The use of this report, in collaboration with the "Retention Center" on the Blackboard system, was assumed to facilitate identification of students who were at risk of failing in the course.

The findings revealed that integration of big data via Blackboard significantly enhanced learner's academic success. It was also found that faculty members helped the struggling students and encouraged their active participation in video lectures, and proactively assisted them to use available tools within the learning environment. In addition, previous experience of students who used the system in previous years revealed instructors' insufficient support during the "Research Methods" course via Blackboard. Despite the fact that Blackboard administrates introduced big data analytics technology as a smart tool to provide instructors with reports that can help, them take decisions regarding how to enhance their students' learning and their delivery of online courses.

2. Literature Review

Big Data management systems originated in industrial organizations that required big data analytics to plan strategies and production systems. In the context of academic institutions like universities adopted e-Learning systems (also known as Big Learning Data system), for developing courses, modules, and lab experiments, facilitating both teachers and students. A Learning Management System would usually be adopted by the universities, blended with social networks, multimedia, and teacher-developed customized learning sources (**Logica; Magdalena**, 2015).

Big Data used in LMSs comprised the records of students' behavior, performance, and other learning-related activities (**Saltz; Krasteva**, 2022; **Aguilar**, 2018), the completion rates and time taken to finish a task or a module; the learning program's effectiveness (**Rahmani *et al.***, 2021), assessment of e-learning strategies and personalizing learning paths of each student based on their strengths and weaknesses. A few LMSs also enabled conducting surveys and feedbacks, forums, and online group collaboration projects to create an interactive online learning environment. LMSs have thus been recognized as digital learning platforms, which include web-based technologies and software applications used by students and faculty to implement, plan, evaluate, monitor, communicate learning, and access educational content. Hence, it is not a surprise that big data utilization has found a home in education, and has offered the recent introduction of LMSs in educational institutions like Moodle and Blackboard (**Rahmani *et al.***, 2021; **Reyes**, 2015). Furthermore, LMS is a tool to create, manage, distribute, and track various types of educational and training materials. To put it differently, LMSs can be claimed to be a crucial component of contemporary and academic curricula delivery. They can also improve teaching and learning in higher education institutions by providing students with online information and instructions (**Abdullah; Ward**, 2016).

Several empirical studies have investigated the impact of Big Data management system in the context of academic institutions (**Chen *et al.***, 2013; **Esomonu; Esomonu; Eleje**, 2020; **Eguavoen; Okodugha; Ugbogbo**, 2022; **Anikweze; Ugoduluwa; Manoma**, 2019; **Cope; Kalantzis**, 2016; **Daniel**, 2015). A recent study (**Opara; Ahiauzu; Oladipupo**, 2023) examines the awareness about Big Data management systems by teachers and instructors in three public universities in Rivers State, Nigeria. The data collected through structured online questionnaire showed a lack of awareness about big data management system tools, though most respondents felt the need and benefits of it. The factors responsible for this lack of awareness were shortage of manpower, non-availability of technology and a consistent use of a LMS. The study recommended to include Big Data management systems and LMS in information technology strategic plans.

A similar study (**Agrawal *et al.***, 2012) made a quantitative comparison of 35 Charter schools and felt the need of introducing the use of Big Data to measure academic effectiveness, and design effective approaches to teach both short term and long term, basic and advanced college-level courses. **Murumba and Micheni** (2017) also argued that by using Big Data Analytics by universigtiies can create best learning environments as well as benefit the society. **Daniel** (2015) felt the need for technology to perform IT-based analytics to measure the performance data and monitor learning tools, policies and processes. **Kelechi *et al.*** (2020), too, agreed that IT analytics can help integrate data related to students' academic, extracurricular and instructional performance. **Dnuggets** (2018) conducted a survey to explore the key benefits of Big Data and showed how educational institutions can utilize Big Data management system to improve and timely access learners' data for decision-making, greater transparency, scalability and better change management. Lastly, a big advantage of Big Data management system is that it has presented to institutions of higher learning a good framework for efficiently utilizing the vast array of data in shaping the future of university education (**Alonso; Arranz**, 2016).

LMSs can be used by students to access various educational resources offered by teachers and meanwhile, interact with classmates (**Homavazir; Gopal**, 2018). In Najran university, Blackboard LMS has been adopted as a platform to manage the educational resources and facilitate synchronous and asynchronous interaction in all courses (**Elsayed**, 2022). For example, as recommended in a few past studies (**Song *et al.***, 2017; **Granić; Marangunić**, 2019; **Byrd**, 2014), it offered course content, a synchronous chat room, an asynchronous forum, blogs, online tests, grade displays, notifications, alerts, calendars, and various multimedia files, like images, music, sound, animations, and video clip. It also provided equipment to record the learner's interactions meticulously by documenting his activities (**Granić; Marangunić**, 2019; **Song *et al.***, 2017). Faculty members, on the opposite, could easily access detailed reports about the learners' activities regarding specific actions, such as video interactions and events involving pauses, slow watching, and rewinding. Detailed reports, of course, included graphical representations that the instructor can review. Reports of Blackboard system can also display each learner's activity on each daily basis or a specific period, with the result that data of complex and unstructured learner interaction can be transformed into actionable information of value to higher education institutions (**Cantabella *et al.***, 2019).

Utilization of big data technique at Najran university has exhibited a set of properties known as the "7Vs,", which include velocity, volume, veracity, variety, visualization, value, and variability (**Ahad *et al.***, 2021). Velocity, the first property, is determined by the exponential growth of the data accumulation rate, which contributes to high processing costs and complexity (**Duda *et al.***, 2018). The data provided by Blackboard platform at Najran University encompass features of velocity, as the data about all learners can be accumulated in the exact time at a high velocity. Volume refers to the continuous generation and compilation of the records of all learners' activities. The complex volume of Blackboard collected data usually includes video interaction events, i.e. pauses, slow watching, and rewinding. Complex data volume, unlike traditional data warehouse analytics, rely on periodic data loads and daily, weekly, or monthly updates, and are analyzed and processed in real-time (**Kumari**, 2018). Reliability is connected to data consistency and accuracy (**Duda *et al.***, 2018), which is relatively simple to achieve in Blackboard platform because every kind of data can be originated from a single source. Variety, on the other part, describes data types collected via Blackboard platform that encompasses detailed statistics about the interactive tools such as, blogs, discussion forums, and video interaction events in unstructured or structured formats. Visualization can generate reports for lecturers to make decisions about improving student learning, because Blackboard platform is equipped with big data analytics techniques such as the intelligent tools integrated into Blackboard. Such reports are algorithm and methods for real-time visual analytics-based reports (**Kumari**, 2018). Value refers to the ability to generate economic value and new knowledge through data utilization. In short, unstructured and complex data can be converted into actionable information and valuable insights with techniques of big data analytics within Blackboard platform to guide the process of decision taking about how to enhance students' learning. Finally, variability indicates data with constantly meaning change (**Kumari**, 2018; **Choi; Ahn; Shin**, 2019), such as video interaction data that vary over time.

3. Methodology

3.1. Research Design

A quantitative research design with semi-experimental approach was used in this study to identify the effect of using big data technique on the academic success of learners. Under this technique, a pre and post design is applied on two homogenous groups which are subject to experimentation. (See Table 1).

Table 1: Quasi-experimental Design.

	Pre-test	Treatment	Post-test
The first group	The deep learning evaluation card	Data analysis technology in Blackboard	The deep learning evaluation card
The second group		Blackboard	

3.2. Sampling

The sample comprised student participants (N=120), randomly selected from the student population studying the graduation program at Najran university. The sample was divided into two equal experimental groups. Students in both groups studied the course content through the video lectures uploaded to Blackboard platform where each one had to independently go over and study each lecture. Later on, participants in the first experimental group were asked to take part in face-to-face classroom sessions to apply what they had learned. The students in the second experimental group were randomly divided into smaller cooperative groups of six students in each, and were asked to practice their acquired skills in the classroom. Equal assistance, when needed, was provided to all students in this group.

3.3. Research Tool (The Achievement Test)

An achievement test was used to assess the academic performance and assess the success level of a sample of students enrolled in the College of Education with regard to the cognitive component of the academic course entitled "Research Methods". The achievement test was designed in light of the course objectives, content, and activities based on the specifications prescribed by Bloom's different levels. The test consisted of (30) objective closed ended questions, out of which (15) were true or false type and (15) were of multiple-choice type. The test was electronically conducted via Blackboard system and was accessible to all students and faculty members.

3.4. Experimental Materials and Procedures

Before delivering the course content to students enrolled in the course via Blackboard system, it was structured and organized into ten separate lectures using video clips. These lectures covered various course topics namely procedural definitions, identification and control of variables, questions and hypotheses, procedures and experimentation, and interpretation of results. Al these materials were organized into ten video clip lectures before uploading them to Blackboard system. Organization of these ten lectures was done after analysis processes of several instructional design models for e-learning using a series of steps to fit the main objectives of the present study. It also took into consideration the learners' characteristics, course goals and content, and related educational activities. Organization also took into account the fact that integration of technology in varied educational settings should be congruent with established theories of teaching and learning (**Alzahrani; Alhalafawy**, 2022; **Alshammary; Alhalafawy**, 2022) and so the use of Big Data techniques in LMSs is in congruence with such a principle because it is one form of technology integration in education.

3.5. Data Analysis

The data analysis technique applied in the present study relied on some theories. For example, the behavioral theory assumes that learning occurs when a conditional association occurs between responses and the stimuli (**Smith; Ragan**, 2004; **Alanzi; Alhalafawy**, 2022). Therefore, it can be claimed that the behavioral theory is present in the current study through the way the course content was delivered via blackboard, the submission of students' research plans, and the way students received support and feedback from their instructors, which were facilitated by data analysis technology. The Cognitive theory, on the other hand, describes learning as a process of restructuring or acquiring of the cognitive structures learners use to process and store information (**Good; Brophy**, 1990). In the present study, delivery of information and content in the LMS was guided by this cognitive theory.

Moreover, there was a focus on video lectures as a component of multimedia learning. Situated learning theory was also accounted for in the present study with an emphasis that learning is not merely acquisition of knowledge but a process of social participation (**Brown; Collins; Duguid**, 1989; **Alzahrani; Alshammary; Alhalafawy**, 2022). In the context of the LMS, this theory stresses the importance of social interaction and social context, which, in the present study, is manifested in activities such as discussions in the chat room and the discussion board.

The data analysis of the first group's video interaction events were conducted weekly using Blackboard reports such as "Student Overview for Single Course" and the associated "Retention Center". Based on these reports, learners in the first experimental group were categorized into three clusters namely very active, active, and non-active (with a higher likelihood of academic challenges). They were then grouped into smaller cooperative groups of six students in each group just like their colleagues in the second group. Each smaller cooperative group involved two students from each cluster. All students in this group were asked to practice learning the course topics in the classroom. Additional support was provided to non-active students or those who are at risk of academic difficulties in the classroom. They were also guided to take immediate corrective actions to enhance their interaction with the video lectures through the retention center in Blackboard, utilizing detailed statistics from the "Student Overview for Single Course" report.

3.6. Ethical Statement

Najran University Deanship of Scientific Research review board granted approval for this study (Approval No.: 444-45-22146-DS). The research methods employed in this investigation adhered to the guidelines outlined in the Helsinki Declaration. In addition, informed consent was also obtained from all participants in this study, and was documented.

4. Results

Right at the outset, prior to administering the achievement test, a group of specialists and experts were chosen to check the test's validity. They were requested for their feedback on various aspects like fitness of questions to the course's cognitive aspects, clarity of language and formulation, suggestions for improvements, and any other recommendations. Agreement in experts and specialists' opinions that reaches 80% is normally accepted by researchers and is considered enough to accept each question. To formulate the final version of the test provided feedback from the jury was accounted for. After that, it was administered to an exploratory sample of (30) students who were not included in the final test application. Its reliability represented by its internal consistency was confirmed using Cronbach's Alpha and the overall coefficient was (0.85). Considering the completion time for the fastest and slowest student to find out the average time needed for the completion of the test, it was found out that (28) minutes were sufficient. Coefficients of each item's ease and difficulty were between (0.27) and (0.73).

After administration of the achievement test to both groups, collected data were classified and analyzed using the Structural Equation Modeling (SEM) with Multiple-group Confirmatory Factor Analysis (CFA) regarding the test aspect mainly procedural definition, identification and control of variables, questions and hypotheses, procedures and experimentation, interpretation of results, and ensure the homogeneity of both experimental groups regarding their academic success. IBM SPSS AMOS 24.0 program was used for this sake.

Figure 1 shows that first experimental group's academic success was minimally affected by any of the procedural definition ($p > 0.05$, ß = 0.13), identification and control of variables ($p > 0.05$, ß = 0.16), questions and hypotheses (ß = 0.11, $p > 0.05$), procedures and experimentation ($p > 0.05$, ß = 0.15), and interpretation of results ($p > 0.05$, ß = 0.09) aspects. Similarly, the second experimental group's academic success was also minimally affected by any of the procedural definition ($p > 0.05$, ß = 0.11), identification and control of variables ($p > 0.05$, ß = 0.12), questions and hypotheses ($p > 0.05$, ß = 0.14), procedures and experimentation ($p > 0.05$, ß = 0.13), and interpretation of results ($p > 0.05$, ß = 0.12) domains. Therefore, results in figure 1 prove that both experimental groups were of similar academic success levels before exposure to the experiment, which indicates that their achievement levels were homogeneous.

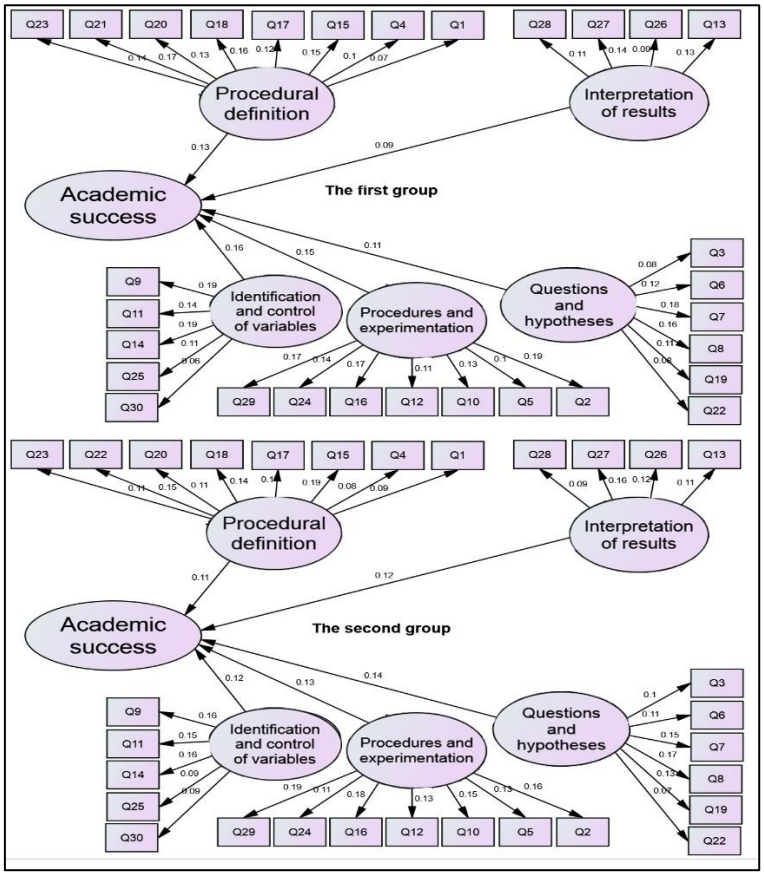

Figure 1: Pre-Multi-group Confirmatory Factor Analysis of the Domains of the Achievement Test for the Two Study Groups.

Participant students' achievement scores in the post-test in both groups were extracted and analyzed. SEM using Multiple-group Confirmatory Factor Analysis (CFA) for statistical analysis and result extraction was used for analysis purposes. Figure 2 illustrates the results showing that for the first experimental group, the aspect of procedural definition was significantly and positively influenced by the utilization of big data technique via Blackboard system ($p < 0.05$, ß = 0.93). There was also a notable positive impact on students' academic success ($p < 0.05$, ß = 0.87). In contrast, procedural identification aspect in the second experimental group showed weak or little benefit from the use of data analysis technology ($p > 0.05$, ß = 0.38), and so it had a minor effect on students' academic success ($p > 0.05$, ß = 0.31).

Figure 2 also reveals that the aspect of identifying and controlling variables of students in the first experimental group was also significant and affected by the utilization of big data technique ($p < 0.05$, ß = 0.85) and so the students' academic success was positive and impacted by this domain ($p < 0.05$, ß = 0.82). Whereas, students' success in the aspect of identifying and controlling variables in the second experimental group was weakly improved because they solely relied on Blackboard system ($p > 0.05$, ß = 0.27) which indicates a minor effect on their academic success ($p > 0.05$, ß = 0.22).

Moreover, Figure 2 demonstrates that utilization of Big data technique in Blackboard system was effective and significant in respect to academic success on the aspect of research questions and hypotheses of students in the first experimental group ($p < 0.05$, ß = 0.91). That is, research questions and hypotheses aspect was of a significant and favorable impact on first experimental group students' academic ($p < 0.05$, ß = 0.89); whereas, performance of students in the second experimental group who solely relied on the Blackboard system regarding the aspect of research questions and hypotheses was not of significant effect ($p > 0.05$, ß = 0.34). In other words, the aspect of research questions and hypotheses was of a minor effect on the academic success ($p > 0.05$, ß = 0.31).

With regard to the aspect of procedures and experimentation for the first experimental group, Figure 2 shows that utilization of Big Data technique in Blackboard system was also of significant effect ($p < 0.05$, ß = 0.83). In other words, the aspect of procedures and experimentation significantly contributed to the development of students' academic success ($p < 0.05$, ß = 0.79). However, success of students in the second experimental group who solely depended on the Blackboard system in accordance with the aspect of procedures and experimentation was weak ($p > 0.05$, ß = 0.23). To put it differently, aspect of procedures and experimentation had a minor effect on the academic success of first experimental group students ($p > 0.05$, ß = 0.19).

Furthermore, Figure 2 also indicates that the aspect of research results interpretation of students in the first experimental group was significantly affected by the utilization of big data ($p < 0.05$, ß = 0.88), which means that this aspect had a substantial and favorable effect on students' academic success ($p < 0.05$, ß = 0.83). On the contrary, the aspect of research results interpretation of students in the second experimental group, who studied through Blackboard system only, was of weak improvement ($p > 0.05$, ß = 0.29) showing a minor effect of this aspect on students' academic success ($p > 0.05$, ß = 0.26).

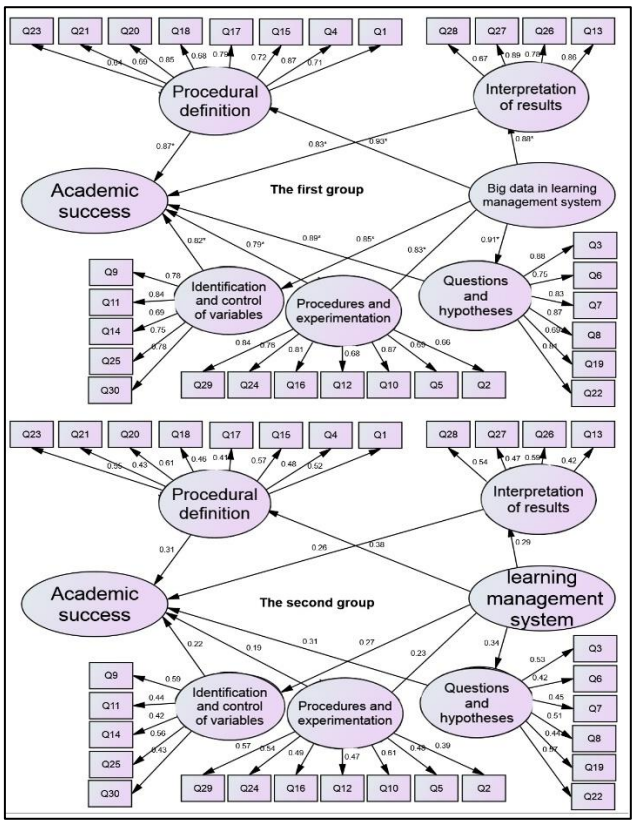

Figure 2: Post-Multiple-group CFA Confirmatory Factor Analysis of the Domains of the Test for the Two Study Groups.

5. Discussion

The present study investigated the academic success of students in the College of Education at Najran University who were enrolled in an academic course titled "Research Methods". Findings indicated that utilization of big data technique within Blackboard system significantly influenced the development of their academic success. These results can be seen in agreement with the findings of previous studies which investigated the impact of using additional features of Learning Management Systems (LMSs) on various learning outcomes. This is consistent with the findings of **Araka *et al.*** (2021), who aimed to assess the perceived usefulness of tools and additional features of LMSs in promoting self-regulated learning and concluded that students did not fully exploit the additional tools and features of LMSs. The study recommended instructors and researchers to provide students with support to enhance self-regulated learning in online environments that incorporate additional features and tools of LMSs.

Similarly, **Tseng** (2020) emphasized that effective utilization of Blackboard LMS tools and features in online courses could positively impact students' academic performance and motivate them to exert more effort in their studies. Additionally, **Nurakun Kyzy; Ismailova, and Dündar** (2018) argued that students' success in e-courses was influenced by various technical characteristics, feedback options, ease of use, and the features and tools of the LMS. **Chen *et al.*** (2018) found that employing embedded Blackboard tools to design engaging learning activities could enhance students' academic performance, equip them with competencies, cater to diverse learning styles, motivate them, and accommodate different learning needs through easy adjustments.

Findings of the present study corroborate the results and recommendations of these previous research studies that had explored the relationship between data analysis and academic success. There is also a study, **Gil *et al.*** (2021), who recommended the use of data analysis technology as a framework for decision-making, based on a set of models to enhance academic success. Additionally, **Cantabella *et al.*** (2019) also revealed, through data analysis technology, that the forum tool enhanced student learning process across various learning methods, including on-campus, online, and blended learning.

6. Conclusion

The purpose of the present study was to identify the effect of utilizing big data technique in learning management systems (LMSs) on the development of students' academic success. An achievement test was employed as a main research tool to fulfill the main objective of the study. Findings showed that the use of big data technique in Blackboard had a significant and positive impact on the development of students' academic success. These findings can encourage faculty members to use this technique because of the advantages of additional LMSs. Findings also can direct educators' attention to the importance of overcoming educational difficulties facing beneficiaries in digital environments. In light of these results, it is recommended organizing training workshops on the skills of using big data technique to develop different learning outcomes. Moreover, it is recommended to conduct studies that explore the possibility of developing academic success through augmented reality.

Despite the fact that the research could be regarded as rigorous and thorough, there were some limitations among which were, the fact that this research project focused on using big data in learning management systems inside Saudi Arabia. Additional research with this technology is required in other countries or regions to assess its applicability and effectiveness in diverse educational settings. Secondly, while this research discovered positive results regarding the role of big data in learning management systems, more research is needed to investigate the possibility of enhancing academic success through using qualitative methods (e.g. case study) that would deepen the understand of the use of Big Data in educational context. Finally, it is important to acknowledge that the sample size used in this study was limited. Conducting more extensive research with a larger and more diverse participant pool, encompassing various fields of study and institutions, could strengthen the generalizability and validity of the findings.

6.1. Acknowledgment

The authors are thankful to the Deanship of Scientific Research at Najran University for funding this work, under the General Research Funding program grant code NU/DRP/SEHRC/12/13.

6.2. Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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