



COGNITIVE LEARNING MODELS AND IMPACT OF COGNITIVE LEARNING ON STUDENT PERFORMANCE ASSESSMENT

¹Dr. Avinash Dhole, ²Dr. Ajay Verma and ³Vikky Kumhar

¹Associate Professor, CSE, Shri Shankaracharya Technical Campus, Bhilai, (C.G), India

²Head & Associate Professor, Mechanical Engg, Shri Shankaracharya Technical Campus, Bhilai, (C.G), India

³Assistant Professor, Department of Mechanical Engineering, Shri Shankaracharya Technical Campus, Bhilai, (C.G), India

Abstract—

Cognitive Learning Model is referred to as a computational representation of human thinking regarding a concept, knowledge domain or a particular skill. The primary focus in this research is to explore influences of cognitive learning over student's performance assessment. Cognitive aspects of learning can relate with thinking processes and mental procedures in order to learn (Samputri2020). Cognitive aspects can influence learning such as memorizing information, understanding a concept, analysis and evaluation. However, previous knowledge and previous learning experience can prevent Cognitive Learning development for a student.

IndexTerms—Cognitive Learning Model, knowledge domain

DOI Number: 10.48047/nq.2022.20.7.NQ33581

NeuroQuantology 2022;20(7):4832-4841

1. Introduction

This research would collect previous works on the agenda limitations in AI-based learning, negative aspects of Cognitive Learning Models and it would represent the educational data mining, and pitfalls of cognitive machine findings based on different aspects such as use of machine learning. It can compare findings regarding student learning in education, applications of artificial intelligence performance in traditional learning process and AI-based in learning, and educational data mining. The techniques learning process as well (Sergis, Sampson and Pelliccione and methods applied in field of cognitive learning; would 2018). This research can lead to proposing new be surveyed and the research gaps or limitations would be approaches that can mitigate the limitations of Artificial 4832 identified. Another research aim is to portray the Intelligence in Education Data Mining. This paper is influences of cognitive machine learning in student's structured with a brief background of the research performance assessment. AI-driven learning is leading to problem, research aim and objectives, methodology, and an era where learning is becoming more flexible in terms literature review. The study includes reviewing related of study duration, coursework content and interactive works in cognitive learning and influence of cognitive learning (Supena, Darmuki and Hariyadi 2021). This learning in student performance. research would survey papers that specifically review **2.0 Cognitive Learning, its Benefits and Psychological Inference Background** students' performance based on AI-driven education **Inference Background** system.

This research can contribute towards identifying limitations in AI-based learning, negative aspects of educational data mining, and pitfalls of cognitive machine learning. It can compare findings regarding student performance in traditional learning process and AI-based learning process as well (Sergis, Sampson and Pelliccione and 2018). This research can lead to proposing new approaches that can mitigate the limitations of Artificial Intelligence in Education Data Mining. This paper is structured with a brief background of the research problem, research aim and objectives, methodology, and literature review. The study includes reviewing related works in cognitive learning and influence of cognitive learning in student performance.

2.0 Cognitive Learning, its Benefits and Psychological Inference Background

Cognitive Learning is an active way of learning that mainly



focuses on helping the learner to increase or maximize information along with experience, thoughts, and senses; mental abilities and perspective. Mental abilities entail these processes are known as cognition (Wartono and different processes in order to absorb and retain the Bartlolona 2018).

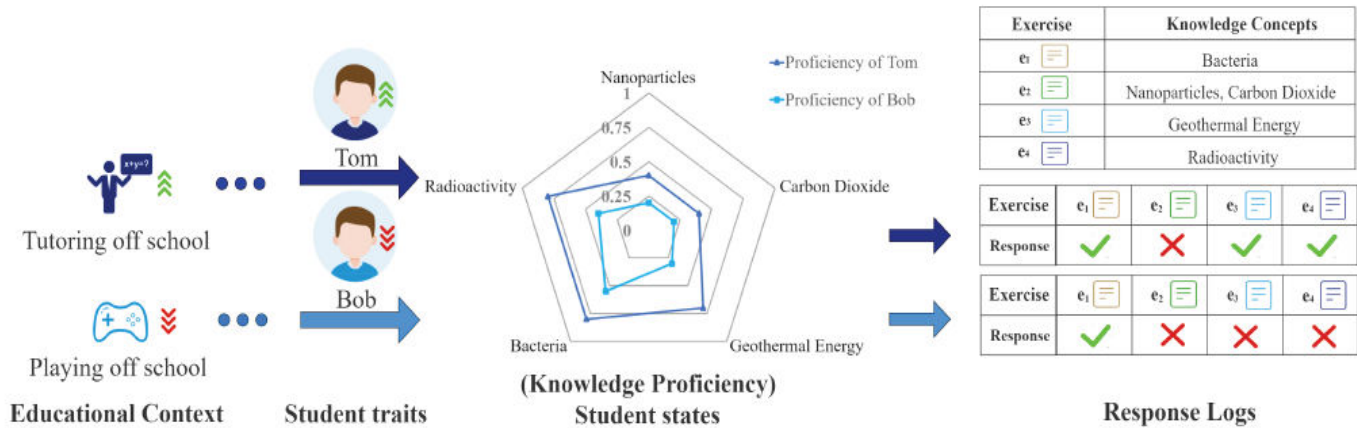


Figure 1: Illustration of Student's Learning Process

(Source: Zhouet *al.* 2021, pp. 2421)

Cognitive learning is important for students to follow as it has following advantages;

1. Cognitive learning theory can increase learning throughout a person's life. The workers and employees can establish learning over previous lessons and ideas along with combining new concepts with existing knowledge.
2. Cognitive learning can enhance confidence in learners and they can approach different tasks while being equipped with a clear understanding of concepts and learning a new skill (Hasanet *al.* 2021).
3. Cognitive learning acquires problem-solving skills to employees and students effectively. They can develop this skill for conducting other challenging tasks in their workplace or life.
4. Cognitive learning can maximize learner's comprehension from new information and they can build a deeper understanding of new concepts and learning materials (Lin and Hwang 2019).
5. Cognitive learning can teach the students to formulate new concepts along with easier perseverance and interpretation of information. It can improve their creativity and students can be led to develop innovative ideas at their tasks.
6. Cognitive learning model can help students to learn new concepts faster as this model can reuse same

learning model to teach different concepts to the students (Widada, Herawaty and Lubis 2018). Students can understand new concepts faster as they becomes familiar with same learning process.

Cognitive Learning theory is massively dominant in psychology to make students learn new things faster. The theory is divided under two categories; observational learning and behavioral learning (Siagan, Saragih and Sinaga 2019). Observational learning is focused with using observation as learning tool and it teaches people positive and negative behavior. For instance, a manager within a company can teach employees positive behavior to maintain while being ethically and socially conscious (Sergis, Sampson and Pelliccione 2018). However, the employees can be trained for other scenarios such as power outage, fire, and other natural hazards. On the other hand, behavioral learning can be initiated with feelings, thoughts and behavior of a personal interaction with each other (Supena, Darmuki and Hariyadi 2021). Thoughts can induce emotions and emotions can lead to specific behavioral responses for a person; it can work in opposite direction as well. Changes behavior can trigger change in feelings and often lead to change in thoughts. Hence, the cognitive learning model can influence both students' behavior and thoughts.

3.0 Research Aim and Objectives

The research aim is to conduct a literature review on the previous works and theory on the agenda Cognitive



Learning Models. The aim is to explore relevant studies to focus on research question: *How does Cognitive Learning Model combine with Machine Learning techniques?*

The findings from the survey can highlight some of the efficient techniques and methods applied in the field of cognitive learning. The review shows the use of machine learning in education, applications of artificial intelligence in learning, and educational data mining as well. Moreover, the survey focuses on another research question: *How does Cognitive Learning Model influence Students' Performance?*

In order to pinpoint the findings as per this question, the influences of cognitive machine learning in student's performance assessment is discussed. Cognitive learning can offer flexibility in study duration; it can customize coursework content and can allow students to participate in interactive learning (Samputri 2020). However, the survey would point out some limitations in AI-based learning, negative aspects of educational data mining, and pitfalls of cognitive machine learning. The survey outcomes can show positive aspects of AI-driven learning and educational data mining (Lin and Hwang 2019). Whereas, these outcomes can be used for comparing traditional learning experience and machine learning-based learning experience as well for students.

4.0 Literature Review on Influence of Cognitive Learning

To emphasize on cognitive theory, it is relevant to understand the ways cognitive learning theory is applied. The cognitive learning theory asks learners to explore thinking and mental processes and it determines how thinking can be influenced from internal and external factors.

4.1 Cognitive Learning Strategies and Activities

There are several learning different types of cognitive learning and several variety of strategies exist that can be utilized for increasing the student achievement (Thomas, Cassady and Heller 2017).

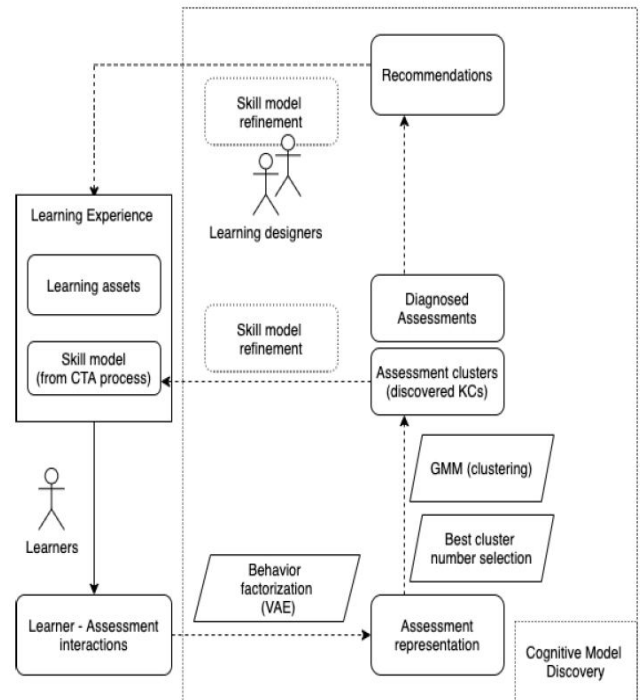


Figure 2: Cognitive Model Delivery Framework

(Source: Zhao et al. 2021, pp. 272)

The cognitive learning strategies can be identified as;
Student should be more interactive: This strategy of interaction motivates student to ask questions and their queries can provide opportunity to the teacher for discussing the topic a bit in-depth for their understanding (Daly-Smith et al. 2018). Students' response and questions can assist the teacher to dissect the concept and focusing on a certain area where the student is facing trouble understanding.

Student should not be afraid of making errors: The teacher should provide students a practice over hands-on problem or simulation over the concept so that students can make mistakes while learning (Lei, Cui and Zhou 2018). Simulation can show the students where they made mistakes and how they can learn from mistakes. Hands-on problem can point out the mistakes the students are doing and teachers can provide assistance for amends to the mistakes.

Students should participate in self-reflection: The teachers

should provide an opportunity for the students to discuss self-reflection (Liet *al.* 2018). Self-reflection helps the students to discuss the mental process and it can help to list out their issues with understanding a theory or concept.

Students should practice thinking aloud: The teachers should show students how to work out a problem or use rational thinking (May and Elder 2018). This thinking aloud practice can help students to work together with group projects, support in one-to-one interactions, and class presentations. Teachers can ask questions to the students or teachers can provide suggestions for helping students to think aloud.

4.2 Machine Learning in Cognitive Learning Domain

Cognitive Computing is a field where Artificial Intelligence and Machine Learning is combined alongside each other. Cognitive Computing refers to combination of machine learning with cognitive mechanism (Dunn and Kennedy 2019). Three aspects are included in cognitive machine learning such as;

Emergency of Learning: The human cognition is primary step to begin learning and this belongs to different stages of perception. The perception includes concept, judgment, and reasoning (Hanushek, Piopiunik and Wiederhold 2019). Perceptual knowledge can be gained through vision, auditory and tactile senses that is translated to rational knowledge. This perceptual knowledge helps to build concept in human brain as emergence of learning.

Complementary Learning System: The complementary learning system building can be a challenge that can bridge between short-term and semantic memory. The systems can learn at scale so that it can reason with purpose and it can interact with humans naturally (Widada and Herawaty 2017). The cognitive computing is driven with cognitive science where self-teaching algorithms that uses data mining, visual recognition, and natural language processing (Laurenset *al.* 2017). Computer can solve problems and it can optimize human processes in cognitive computing.

Evolution of Learning: Evolution introduced changes in human brain capabilities and language is a major part of learning or cognitive abilities (Das, Mandal and Basu2020).

Therefore, evolution of learning should not only adapt to the changes in real-time situation; but it should accept the changes in learning mechanism.

4.3 Applications of Artificial Intelligence in Education System

There are several applications of Artificial Intelligence in learning and in education sector. There are AI tools and technologies available that can be used for introducing automation in educational field and reducing the gaps between grading systems (Akmamet *al.* 2018). Some important applications of AI in education sector are;

Grading Software: AI-powered grading system includes machine learning algorithm for creating systems that can collect important data for grading assignments from papers. The software can grade the papers on their own based on replicating human grading process; the system learnt the grading process from the teachers (Kostariset *al.* 2017). Teachers' input is combined with AI for grading papers, tests, and essays within couple of minutes or even in different languages. Existing virtual environment or cloud-based platform can integrate the AI-based grading software (Wartono and Bartlolona 2018). This software is useful when the teacher is involved in more value-oriented jobs such as creating lecture courses and creating video content rather than just grading papers.

Voice Assistants: The voice assistants are useful engagement and creating a convenient way to include learning for students at home and it helps users to schedule learning with calendar (Hasanet *al.* 2021). Voice assistant can play coaching instructions anytime and it can provide faster responses to students' basic questions. Hence, voice assistants can save time for teachers and students, it can provide several learning opportunities to a specific community, and it can provide personalized education courses as well.

Tasks of Admins: AI have eliminated administration tasks, it has reduced manual works in schools, universities, and colleges (Lin and Hwang 2019). These administration tasks can be scheduling and rescheduling lectures, collecting attendance, grading papers, record keeping, and accounting assistance. Manual and tiresome works need not to be completed with staffs where, AI tools can be useful (Widada, Herawaty and Lubis 2018). AI tools can

4835



help with administration tasks so that teachers can invest their time to improve teaching quality, increase lecture value, and add more interactions in class; rather than spending time in paperwork reducing their work pressure. *Personalized Learning:* The AI tools can help learning a tailor-made process and customized for individual learners' requirements. The personalized learning can identify knowledge gaps, specific instructions, tests, and necessary feedbacks from learners to progress in the course (Siagan, Saragih and Sinaga 2019). AI-powered platform such as tools, educational games, and educational software are developed with strategies for students so that they can learn as per their abilities, time, and requirements of practice (Sergis, Sampson and Pelliccione 2018). Classroom with AI assistance can help teachers to customize their lesson plans with individual students' needs and this learning routine can be much more adaptive. It can help building a knowledge foundation for different types of learners.

Smart Course Contents: The smart content can include digital guide, instructional snippets, textbooks, and videos to operate AI tools for creating customized environments for educational purpose (Samputri 2020). The educational organizations and institutes can create smart course content based on strategies and goals. Personalized content is a strategic goal for learners and AI tools can achieve this feature. Schools can create virtual environments for students where web-based lessons can be taught to the students (Supena, Darmuki and Hariyadi 2021). AI monitoring and evaluation process can be conducted with streamlining the content for different learners. They can match their pace of learning and several students can learn from streamlined content. Based on wrong answers or mistakes done from several students, the AI-based tool can focus on those areas to add useful tips and fun exercise to fill the learning gaps (Thomas, Cassady and Heller 2017). Therefore, smart content can take effective measures to help students grasp concept without falling into common mistakes.

Virtual Learning Environment: Virtual Learning environment can help students to connect with mobile devices and laptops to access study content interactively

(Daly-Smith et al. 2018). The virtual learning environment can provide learning experience in a group, counselling students, and immersive learning experience. In addition, learners can help other learners with interactive virtual simulations with adding their own opinions about the course, learning difficulties, and quick answers to fellow learners. *Intelligent Tutoring:* The tutoring can be improved with Artificial Intelligence and it can be equipped with personalized feedbacks from students (Lei, Cui and Zhou 2018). However, the intelligent tutoring cannot entirely replace a human teacher; Intelligent Tutoring is not yet advanced enough to replicate teaching process followed by a human being (Liet et al. 2018). This application can help with scenarios where small lessons can be delivered to students in absence of teacher for a limited time.

4836

4.4 Educational Data Mining in Cognitive Computing

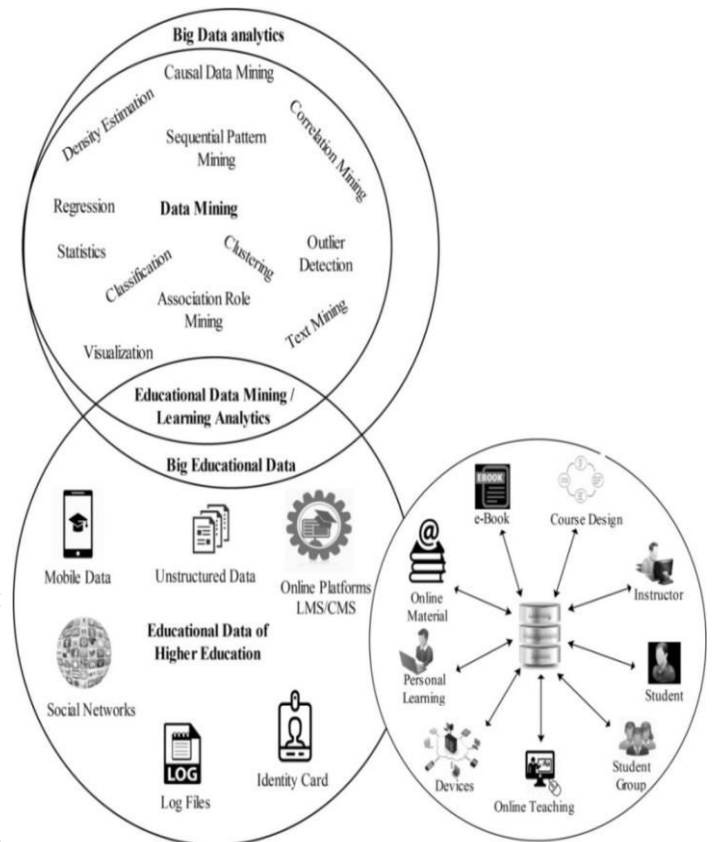


Figure 3: Illustration of Educational Data Mining

(Source: Aldowah, Al-Samarraie and Fauzy 2019, pp. 14) from the duration 2017 to 2022. Articles should be Currently, data collection volume for many educational institutes became massive and storing massive data cannot be performed manually anymore. Educational Data Mining is known as new discipline that has emerged from applications of data mining techniques over educational data (May and Elder 2018). Educational Data Mining became popular with its data volume and different research areas such as pattern recognition, information visualization, computational modeling, psychometrics, and improving educational assessments. There are several methods such as algorithms and techniques that are used for educational data mining (Dunn and Kennedy 2019). Most often classification, clustering, prediction, and association are used for educational data mining.

5.0 Research Methodology

This paper is focused on secondary data analysis and entire approach of the research is based on reviewing related works. The review paper is prepared based on two research questions that are;

RQ 1: How does Cognitive Learning Model combine with Machine Learning techniques?

RQ 2: How does Cognitive Learning Model influence Students' Performance?

These two questions are considered while collecting related works on the agenda. The search keywords or strings were chosen as 'educational data mining', 'cognitive learning', 'cognitive learning strategies', 'machine learning in cognitive learning', 'artificial intelligence in cognitive learning', 'cognitive computing', and 'influence of cognitive learning over student performance'. These strings were included with 'student learning' so that searching criteria meets the identified research questions. However, the 'student learning' strings needs to included in the search criteria as there are several other research papers they have conducted the same cognitive learning study over different research candidates such as nurses, employees, interns, and others.

The data from articles is chosen based on some criteria such as article should meet search keyword criteria, articles should be data mining or machine learning research papers, and articles should be included either

available full-text and should be in English language. The data extraction from the articles are based on fields as; findings about cognitive learning, data mining approaches, artificial intelligence-based learning, educational data mining, and research gaps.

While conducting the research work, the data collection is performed based on two separate sections. One section includes literature survey and another section is findings and discussion of the study. Literature review section encompasses theoretical background of Cognitive Learning Theory as a strategy and learning activities identified for the same. The cognitive computing domain is studied with highlighting combination of machine learning and artificial intelligence into the field.

Application of artificial intelligence in education sector is discussed showing different aspects of learning that became improved recently. In addition, educational data mining domain is focused within the cognitive learning agenda as well. Moreover, influences of cognitive machine learning in students' performance is determined. The negative impacts of AI-based learning and cognitive machine learning are addressed to portray the limitations of the study as well. In findings and discussion section, analytical viewpoint is utilized and collection data is discussed under two different research questions. Findings are aligned with research objectives to mention the overall contribution of the study.

6.0 Findings and Discussion

Based on the literature survey, this section is prepared to align the research questions with findings and limitations of the findings. The limitations of the findings are mentioned to identify an analytical aspect about the research questions.

6.1 Limitations in Cognitive Learning Model

In a brief, education society would be highly benefitted using AI-driven teaching and lecture series. AI-driven courses have several flexibility and advantages that are mentioned in the literature survey section earlier (Abu Saa, Al-Emran and Shaalan 2019). However, the downside to the cognitive learning model are identified in brief as;



lack of human interactions, unemployment of teachers, properly.

communication barrier, maintenance issues, reducing the ability to think for students, lack of emotional intelligence, and causing laziness among the students (Khan and Ghosh 2021). The disadvantages has other concerns of data privacy over cloud platforms. The limitations in AI are mentioned as following;

Lack of human interactions: Artificial Intelligence is useful tool for teaching and educational growth; however, it makes student to lose their practicing routine and learning social skills. When students attend AI-based learning classes more, they are not exposed to real people during class and hence, they lack social skills (Nye, Prasad and Rounds 2021). These students would need to leave their school to interact with other people, as interaction with other people is important socially as adults.

Unemployment of teachers: The AI in education is making teachers to lose their jobs and these programs are helping students to learn on their own (Giannakaset al. 2021). Human instructor is not necessarily required to guide a student throughout lessons or even conducting grade assignments. Integration of AI would lead to unemployment of teachers leading to AI teaching students without human intervention (Heet al. 2021). Therefore, workload gets lower with assistance of AI, institutes can assign more than one instructor per student, and multiple teachers would not be required anymore.

Communication barrier: AI in education creates a massive communication gap between the learner and the teacher. AI cannot communicate or connect with students as well as a human instructor or teacher would connect with a human student (Cartiff, Duke and Greene 2021). AI can introduce more advanced Learning Solutions however; communication barrier exists such as addressing basic problems before certain features comes online.

Maintenance issues: AI has a limited knowledge base compared to human teachers. AI engine can show some unexpected consequences when AI reaches its capabilities. Hence, expert should be employed to monitor AI-based solutions (Zhao et al. 2021). Moreover, AI-based systems would require brute-force maintenance issues where developers would require to conduct maintenance process on their own to keep the system working

Reducing the ability to think for Students: The AI takes out thinking power from students; it makes them more system-dependent and students would be reaching to a decision once, the AI-driven system guides them (Zhou et al. 2021). Hence, students lack in making decision on their own.

Lack of emotional intelligence: The AI brings lack of emotional intelligence to the students and this trait could be preferred for several researchers and students (Gao et al. 2022). AI can help people to learn a specific course or curriculum; whereas, teachers can help students to learn social skills such as empathy and communication with others.

Causing laziness among the students: The AI-based tools are being used for grading students' and there is very small incentive that is used for ensuring they work hard (Desai, Ramasamy and Kiper 2021). The technology can encourage laziness in students when AI makes things easier and convenient for people.

Consequences in Educational Data Mining: The data mining has some disadvantages and it can be either security or privacy (Redifer, Bae and Zhao 2021). It should be clear that information could be used and shared later. Data Mining tools and techniques generally use massive data and there is a huge cost to at the implementation phase (Mehrvarzet al. 2021). This EDM development approach would require IT experts in order to preprocess data and identify the best model and technique for analysis.

6.2 Influences of Cognitive Machine Learning in Student's Performance Assessment

Student performance assessment became automatic with AI-driven tools or platform. AI is known as an asset to help student for opting nontraditional education experience. Use of AI can help giving tests and assignments to the students and after paper evaluation, AI can provide individual assessments for the students (Cartiff, Duke and Greene 2021). The assessments of student are very important to estimate where, natural teachers would calculate the entire scoring or grading evaluation marks. AI integration helps the process of estimating student results for teachers. The grading

system is developed based on performance of AI in education sector. AI system should be trained it teachers' and teachers. Students tend to lose focus over priority to grading patterns (Redifer, Bae and Zhao 2021). The grading patterns would be used to train the model. After training the model, if the algorithm works, then the outcome would be similar to teachers' grading process. Artificial Intelligence-based grading system can put grade on student's essay based on some certain factors or attributes; that are identified as grammar, usage of grammar, style of word repetition, lexical complexity, sentence variety, discourse structure, and source use for referencing (Nye, Prasad and Rounds 2021). Artificial Intelligence is used for benefitting the computer-assisted tests and achieving more developments in machine learning field. The AI engine can replace the human tutor and student assessment would be automated from AI tools (Giannakaset *al.* 2021). AI applications are growing very fast and in future, AI devices would be able to communicate with users flawlessly. AI enables the computers to learn automatically and it can set the procedures where the computer can make future decisions. Machine learning algorithms can learn from patterns, relationships, associative rules between data. Artificial Intelligence learns from earlier experience of teachers and students in a specific coursework.

7.0 Conclusion

In conclusion section to this review paper, it can be stated that Cognitive Learning is hugely improved with integration of machine learning and artificial intelligence. Manual teaching process and time-consuming works in teaching such as taking attendance, scheduling lectures, and grading papers; can be easily diverted to AI-assisted tools. Hence, the AI-based tools can help entirely the administration works; whereas, teachers and students can interact with each other for improving study quality. Classification is commonly used data mining technique for segmenting educational data under different categories or classes. This technique can help with analyzing data so that outcomes can be predicted. The classification can be used for accurate prediction of target class and classifier should be used for determining the parameters required for the classification. As per the overview of negative aspects of AI-driven education system, advanced

technology tends to make people lazier for both students learn coursework, most of them are lingering the learning process as they have the control to schedule learning sessions all by themselves with one-button-click away. AI is reducing traditional teaching jobs; hence, there is no clear way to handle the lack of human interaction in AI-driven education system.

REFERENCES

- [1] Abu Saa, A., Al-Emran, M. and Shaalan, K., 2019. Factors affecting students' performance in higher education: a systematic review of predictive data mining techniques. *Technology, Knowledge and Learning*, 24(4), pp.567-598. **4839**
- [2] Akmam, A., Anshari, R., Amir, H., Jalinus, N. and Amran, A., 2018, April. Influence of learning strategy of cognitive conflict on student misconception in computational physics course. In *IOP Conference Series: Materials Science and Engineering* (Vol. 335, No. 1, p. 012074). IOP Publishing.
- [3] Aldowah, H., Al-Samarraie, H. and Fauzy, W.M., 2019. Educational data mining and learning analytics for 21st century higher education: A review and synthesis. *Telematics and Informatics*, 37, pp.13-49.
- [4] Cartiff, B.M., Duke, R.F. and Greene, J.A., 2021. The effect of epistemic cognition interventions on academic achievement: A meta-analysis. *Journal of Educational Psychology*, 113(3), p.477.
- [5] Daly-Smith, A.J., Zwolinsky, S., McKenna, J., Tomporowski, P.D., Defeyter, M.A. and Manley, A., 2018. Systematic review of acute physically active learning and classroom movement breaks on children's physical activity, cognition, academic performance and classroom behaviour: understanding critical design features. *BMJ open sport & exercise medicine*, 4(1), p.e000341.
- [6] Das, S., Mandal, S.K.D. and Basu, A., 2020. Identification of cognitive learning complexity of assessment questions using multi-class text classification. *Contemporary Educational Technology*, 12(2), p.ep275.



- [7] Desai, U., Ramasamy, V. and Kiper, J., 2021, April. Evaluation of student collaboration on canvas LMS using educational data mining techniques. In *Proceedings of the 2021 ACM southeast conference* (pp. 55-62).
- [8] Dunn, T.J. and Kennedy, M., 2019. Technology enhanced learning in higher education; motivations, engagement and academic achievement. *Computers & Education*, 137, pp.104-113.
- [9] Gao, L., Zhao, Z., Li, C., Zhao, J. and Zeng, Q., 2022. Deep cognitive diagnosis model for predicting students' performance. *Future Generation Computer Systems*, 126, pp.252-262.
- [10] Giannakas, F., Troussas, C., Voyiatzis, I. and Sgouropoulou, C., 2021. A deep learning classification framework for early prediction of team-based academic performance. *Applied Soft Computing*, 106, p.107355.
- [11] Hanushek, E.A., Piopiunik, M. and Wiederhold, S., 2019. The value of smarter teachers international evidence on teacher cognitive skills and student performance. *Journal of Human Resources*, 54(4), pp.857-899.
- [12] Hasan, H., Dedi Hermanto Karwan, D., Een, Y.H., Riswanti, R. and Ujang, S., 2021. Motivation and Learning Strategies Student Motivation Affects Student Learning Strategies. *Despite being a popular research subject internationally, self-regulated learning is relatively under-investigated in the Indonesian context. This article examined student learning motivation and its use as an indicator to predict student learning strateg*, 10(1), pp.39-49.
- [13] He, X., Wang, H., Chang, F., Dill, S.E., Liu, H., Tang, B. and Shi, Y., 2021. IQ, grit, and academic achievement: Evidence from rural China. *International Journal of Educational Development*, 80, p.102306.
- [14] Khan, A. and Ghosh, S.K., 2021. Student performance analysis and prediction in classroom learning: A review of educational data mining studies. *Education and information technologies*, 26(1), pp.205-240.
- [15] Kostaris, C., Stylianos, S., Sampson, D.G., Giannakos, M. and Pelliccione, L., 2017. Investigating the potential of the flipped classroom model in K-12 ICT teaching and learning: An action research study. *International Forum of Educational Technology and Society-*
- [16] Laurens, T., Batlolona, F.A., Batlolona, J.R. and Leasa, M., 2017. How does realistic mathematics education (RME) improve students' mathematics cognitive achievement?. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(2), pp.569-578.
- [17] Lei, H., Cui, Y. and Zhou, W., 2018. Relationships between student engagement and academic achievement: A meta-analysis. *Social Behavior and Personality: an international journal*, 46(3), pp.517-528.
- [18] Li, J., Ye, H., Tang, Y., Zhou, Z. and Hu, X., 2018. What are the effects of self-regulation phases and strategies for Chinese students? A meta-analysis of two decades research of the association between self-regulation and academic performance. *Frontiers in Psychology*, 9, p.2434.
- [19] Lin, H.C. and Hwang, G.J., 2019. Research trends of flipped classroom studies for medical courses: A review of journal publications from 2008 to 2017 based on the technology-enhanced learning model. *Interactive Learning Environments*, 27(8), pp.1011-1027.
- [20] May, K.E. and Elder, A.D., 2018. Efficient, helpful, or distracting? A literature review of media multitasking in relation to academic performance. *International Journal of Educational Technology in Higher Education*, 15(1), pp.1-17.
- [21] Mehrvarz, M., Heidari, E., Farrokhnia, M. and Noroozi, O., 2021. The mediating role of digital informal learning in the relationship between students' digital competence and their academic performance. *Computers & Education*, 167, p.104184.
- [22] Nye, C.D., Prasad, J. and Rounds, J., 2021. The effects of vocational interests on motivation, satisfaction, and academic performance: Test of a mediated model. *Journal of Vocational Behavior*, 127, p.103583.
- [23] Redifer, J.L., Bae, C.L. and Zhao, Q., 2021. Self-efficacy and performance feedback: Impacts on cognitive load during creative

- 101395.
- [24] Samputri, S., 2020. Science process skills and cognitive learning outcomes through discovery learning models. *European Journal of Education Studies*.
- [25] Sergis, S., Sampson, D.G. and Pelliccione, L., 2018. Investigating the impact of Flipped Classroom on students' learning experiences: A Self-Determination Theory approach. *Computers in Human Behavior*, 78, pp.368-378.
- [26] Siagan, M.V., Saragih, S. and Sinaga, B., 2019. Development of Learning Materials Oriented on Problem-Based Learning Model to Improve Students' Mathematical Problem Solving Ability and Metacognition Ability. *International electronic journal of mathematics education*, 14(2), pp.331-340.
- [27] Supena, I., Darmuki, A. and Hariyadi, A., 2021. The Influence of 4C (Constructive, Critical, Creativity, Collaborative) Learning Model on Students' Learning Outcomes. *International Journal of Instruction*, 14(3), pp.873-892.
- [28] Thomas, C.L., Cassady, J.C. and Heller, M.L., 2017. The influence of emotional intelligence, cognitive test anxiety, and coping strategies on undergraduate academic performance. *Learning and Individual Differences*, 55, pp.40-48.
- [29] Wartono, M. and Bartolona, J.R., 2018. Influence of problem based learning learning model on student creative thinking on elasticity topics a material. *Jurnal Pendidikan Fisika*.
- [30] Widada, W. and Herawaty, D., 2017, August. The effects of the extended triad model and cognitive style on the abilities of mathematical representation and proving of theorem. In *1st Annual International Conference on Mathematics, Science, and Education (ICoMSE 2017)* (pp. 231-237). Atlantis Press.
- [31] Widada, W., Herawaty, D. and Lubis, A.N.M.T., 2018, September. Realistic mathematics learning based on the ethnomathematics in Bengkulu to improve students' cognitive level. In *Journal of Physics: Conference Series* (Vol. 1088, No. 1, p. 012028). IOP Publishing.
- [32] Zhao, J., Thille, C., Gattani, N. and Zimmaro, D., 2021, June. A Novel Framework for Discovering Cognitive Models of Learning. In *Proceedings of the Eighth ACM Conference on Learning@Scale* (pp. 271-274).
- Zhou, Y., Liu, Q., Wu, J., Wang, F., Huang, Z., Tong, W., Xiong, H., Chen, E. and Ma, J., 2021, August. Modeling context-aware features for cognitive diagnosis in student learning. In *Proceedings of the 27th ACM SIGKDD Conference on Knowledge Discovery & Data Mining* (pp. 2420-2428).**

