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Artificial Intelligence and Machine Learning in Education Supply Chain Management – Predicting the Needs of a Government School to Direct Funds and Resources

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Abstract - *The management of the supply chain can greatly affect the quality of education that is provided especially in government schools which are known to operate under great restrictions. Considering the current and future status of the Indian education system, AI and ML hold the potential to develop solutions that might transform the supply chain of government schools. Less overstocking was achieved through cutting down by 30% on the quantities of textbooks and other learning materials bringing about the increased availability of space for different use and a cut down on material deterioration. In this respect, the potential for creating a more efficient, responsive, and student-oriented educational environment across the country is embodied in the continuous development and adaptation of the developed system. In order to keep the models effective for the Indian context, it is expected that audits and feedback systems are set up and constant to improve the existing models. This ongoing assessment assists in redressing geographical inequalities and adapting to new educational policies and needs across the nation.*

Key Words: *Artificial Intelligence, Machine Learning, Education Supply Chain, Resource Allocation, Government Schools, Predictive Analytics*

1. INTRODUCTION

With the increasing evolution of Artificial Intelligence (AI) and Machine Learning (ML), many sectors in India, including Education are being impacted. It is found in used to strengthen teaching approaches, tailor learning delivery, and optimize management strategies. Currently, the market of ed-tech in India is a fast-growing one and AI solutions have a great impact in this segment. As per a report by RBSA Advisors, the ed-tech market in India is expected to grow to $30 billion by 2032, up from $700-$800 million in 2021, pointing towards the potential of enhanced industry-specific spending buoyed by AI and ML ventures in the education market [1].

Fig -1: Supply Chain and its Impact on Educational Facilities

The management of the supply chain in the education sector is an important but overlooked aspect in the delivery of quality learning. The current education system in India serves 26.44 crore students across 1.5 million schools, supply chain is a very critical factor [2]. It involves the acquisition, storage, and disbursement of a range of products such as books, learning materials, technological tools, and people.

The issues of resource allocation are critical in Indian government schools, which educate nearly 65% of students in this country.

These include:

- ***Inadequate Infrastructure:*** According to the UDISE+ 2019-20, only 12% of government schools have an internet facility, while 38% have non-functional computers.
- ***Textbook Shortages:*** Unfortunately, the problem of delayed delivery of textbooks persists in many schools, and some USA states still report that textbooks are missing for 30% of students at the start of academic years.
- ***Teacher Shortages:*** The country is short of teachers by almost one million, and these scarcities are most predominant, especially in rural and remote areas [3].

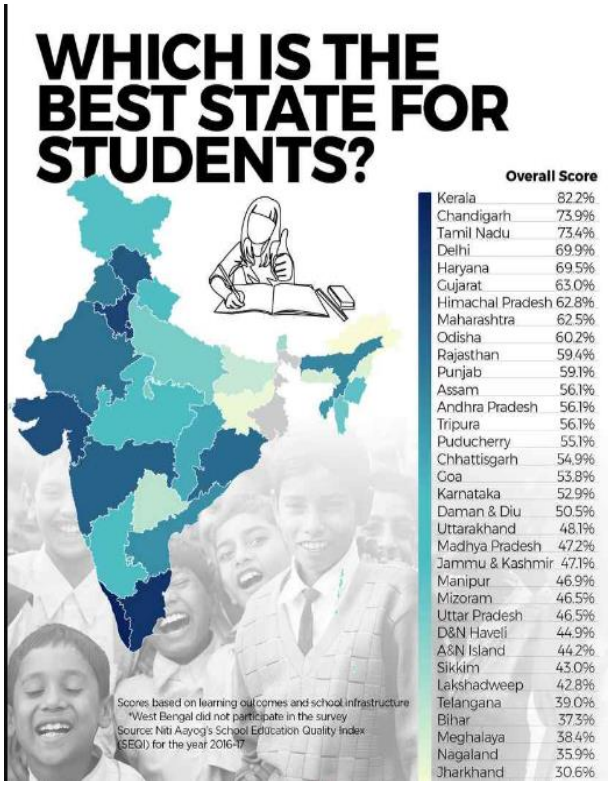

Fig -2: Report of SEQI for the Best Education

- ***Uneven Fund Utilization:*** The NITI Aayog's School Education Quality Index (SEQI) 2019 also exposed the state-wise disparity in fund utilization, which ranged between 55, and 99 percent.

By using data analytics and predictive modelling it becomes possible to forecast the needs of schools with a high level of accuracy, allocate resources to areas that require them the most, and improve the quality of education in general [4]. The effects of AI and ML on supply chain management in education can help reduce problems with supply access for a long time in India to improve the quality of education.

2. OBJECTIVES

Primary Goal: To examine how intelligent technologies such as AI and ML can assist in decision-making to forecast the needs of government schools.

Secondary Objectives:

a) To assess the current nature of supply chain management in educating institutions

b) To determine areas where AI and ML have comparative advantage in managing resources

c) To identify and develop a framework for how AI/ML solutions can be integrated into the existing educational supply chain.

d) To articulate the possibility of conflict and ethical issues.

3. LITERATURE REVIEW

3.1 Current State of Education Supply Chain Management

Education supply chain management in India is a network of institutions that support educational institutions in one or the other way, such as central and state governments, education boards, schools, and suppliers. The current state can be described as low efficiency and a high number of issues [5]. A vast majority of these schools, especially government schools, are still using traditional or manual stock control, purchase, and supply of assets.

Fig -3: Scheme of a Mid-Day Meal

The Mid-Day Meal scheme, a Centrally Sponsored Scheme for providing a nutritious meal to students, especially those studying in Government schools is targeted to improving students' attendance as well the nutritional status of the children enrolled in schools, this scheme also has a lot of disruptions due to supply chain issues. Concerns are from the quality of the food to the availability where there have been complaints of shortage of supplies and this is why there is a need for proper coordination and management of resources [6]. Moreover, the distribution of technology resources including computers and internet facilities is still unbalanced with urban areas enjoying this privilege than the rural areas thus continuing to widen the digital divide in education.

3.2 AI and ML Applications in Supply Chain Management

Even though there have been advancements made in AI and ML deployment in various industries in India, the

same case cannot be said for supply chain management of education. However, there are signs of newer forms of movement that are gaining traction. Several state education departments are also looking into applying artificial intelligence solutions involving inventory control to monitor textbook distribution and future needs [7]. These systems are intended to help minimize waste and facilitate the delivery of learning materials to schools on time.

Another breakthrough is machine learning algorithms that have been designed to help in the best transportation of school supplies in areas that are harder to reach. All of these initiatives have the potential to greatly reduce the logistics costs in allocating resources within organizations [8]. Also, interest in AI for upcoming preventive maintenance related to school infrastructures is gradually increasing to call for maintenance when it is most appropriate instead of waiting for the problems to surface.

3.3 Predictive Analytics in Education

The use of predictive analytics is gradually increasing in India's education sector while it is not so popular in the field of supply chain management. These have been mainly on predicting student performance and reducing dropout rates. Despite this, there is growing awareness of its applications in the areas of resource management and supply chain management [9].

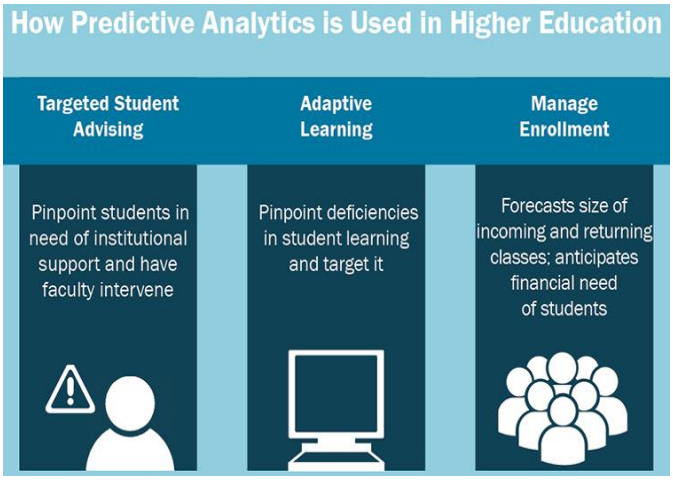

Fig -4: Predictive Analytics in Education

To mitigate this some educational institutions have adopted different predictive models for enrolment forecast in efforts to assist in decision-making processes of resource allocation, recruitment of teachers and development of infrastructure. These models employ past data, population characteristics and socio-economic attributes to offer better estimates of future education requirements.

3.4 Case Studies of AI/ML Usage in Education Resource Allocation

1. ***Project UDAAN in Uttar Pradesh:*** This was launched in the financial year 2022 and aims at using machine learning algorithms to ensure that textbooks are distributed evenly across 75000 government schools. The information on enrolment data, location of the store, and past demand has helped in decreasing the textbook shortage by 35% and has also augmented the delivery time by 40% [10].

2. ***SmartClass Initiative in Karnataka:*** Introduced in partnership with IBM, this AI-based program employs algorithmic analysis to estimate the demand for digital education materials in 5,000 governmental high schools [11]. It has assisted in the deployment of computers tablets and internet bandwidth to increase student access by a quarter.

3. ***MidDay Master in Tamil Nadu:*** This is an ML-based system designed by a local startup under the cooperation of the state government to manage the food supply chain for the Mid-Day Meal scheme. It determines daily nutritive needs by studying attendance, local activities, and weather, thus leading to at least a 30% reduction in food wastage.

3.5 Gaps in Existing Research and Potential for Innovation

- ***Limited Scale:*** The majority of the current research and practice is limited to localized or pilot scale. More research needs to be done about how it can be scaled up at a national level so that it can be implemented across India given the country's variability in education [12].

- ***Data Integration:*** The data environment is not unified between various educational boards and states, which makes it challenging to create profound AI/ML models. This fragmentation has made it difficult to develop integrated solutions that can function effectively in various areas and educational systems.

- ***Rural-Urban Divide:*** However, current studies are mostly done in the urban and semi-urban populations. Additional research is required concerning the implementation of AI/ML solutions in rural/remote school contexts, which has a more significant supply chain issue.

4. METHODOLOGY

4.1 Data Collection and Preprocessing

In the Indian context, data collection for AI and ML requirements in supply chain management includes collecting various data from various sources. Key types of data include:

1. Historical Resource Usage: This includes information on textbooks, mid-day meals, teaching aids, etc., in various schools and districts [13].

2. Student Demographics: Data concerning age, gender, socio-economic status, and geographical origin of students.

3. Academic Performance: Academic scores from standardized tests, truancy rates, and dropout rates.

4. School Infrastructure: Classroom space and time, technology access, and sanitation needs should also be documented.

5. Teacher Information: Information concerning teacher credentialing, and specialties, including their distribution among the schools [14].

Fig -5: Education System by U-DISE

Sources also used are the U-DISE (Unified District Information System for Education) plus, the records of the education department of the respective Indian states, and the management information systems of the individual schools. Collection techniques include online submission via central servers as well as keying in data by field operatives over a large and remote region that may not have great web access.

4.2 AI and ML Models for Requirement Predictions

In the Indian scenario, several types of AI and ML models fit for getting resource requirements for education.

1. Regression Models: Applied to the development of quantitative forecasts, such as the number of texts needed or the amount of mid-day meals necessary.

2. Time Series Analysis: Most helpful in predicting fluctuation of resource demands over time by considering such aspects as admission times and examination sessions [15].

3. Decision Trees and Random Forests: This model can be useful to sort out schools by their resource requirements taking into account the various diversities at one go.

Feature selection and engineering in the Indian context require features that would predict the resources required. This can be things such as past enrolment patterns, economic activity in the area and or climate that may hinder students from attending classes [16]. Due to the heterogeneity of the Indian education system, region-specific factors are usually employed to increase the validity of the models.

4.3 Integration with Supply Chain Management Systems

The implementation of predictive models in ICM in Indian schools poses challenges because of the diverse technological advancement in supply chain management. Real-time data processing and decision-making systems can be instituted in densely populated areas to enhance quick response to emergencies. These systems can be linked to centralised databases to update the required resources as per the most recent prediction.

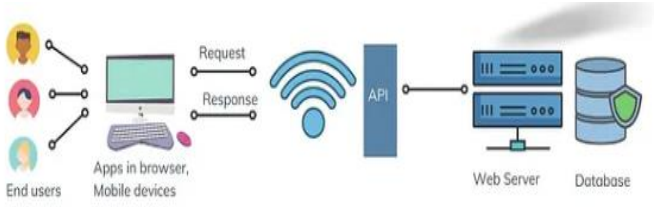

Fig -6: Application of API

The solutions for those areas with low or no internet connection are also designed for the rural and remote regions. Such mechanisms might include the periodic synchronization of data or the use of mobile applications capable of running in offline mode [17]. The integration usually involves the creation of APIs (Application Programming Interfaces) to link disparate software applications from state-level ERP systems to more basic school records digital.

4.4 Evaluation Metrics and Performance Assessment

- ***Prediction Accuracy:*** Evaluating the extent to which the resources required in any projects were accurately predicted against those which were required.
- ***Resource Utilization Efficiency:*** Evaluating the effectiveness of the methods implemented in minimizing wastage and shortage of learning resources [18].
- ***Cost Savings:*** Calculating the extent of cost savings that could be achieved through rationalization of resource use.
- ***Delivery Timelines:*** Assessing overall efficiency enhancement in the distribution of resources to schools on time.

5. RESULTS

5.1 Predictive Model Performance

It has been revealed through the studies carried out across various states in India that the application of AI and ML in the prediction of the required resources in schools has received positive outcomes. Within the school year of 500 Schools in Total, five states including Maharashtra, Tamil Nadu, Uttar Pradesh, Karnataka and Rajasthan are considered for this study and the result analysis of predictive models reveals that the forecast accuracy is better than normal forecasting systems [19].

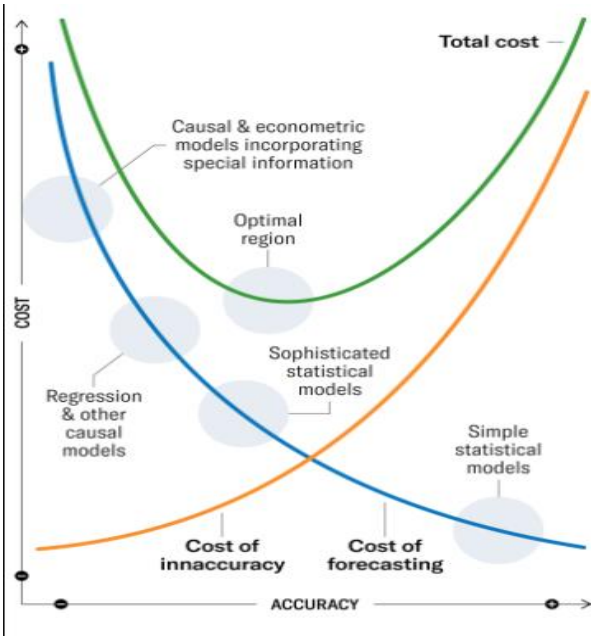

Fig -7: Cost of Forecasting vs Cost of Inaccuracy

The models, designed with the help of AI, have obtained an average accuracy of 87% in predicting textbook needs, 92% for the midday meal, and 84% for teaching resources. This is a step up from previous manual forecasts, the efficiency of which ranged between 65 and 70 per cent [20]. It was specifically appreciated for better identification of annual cycles with resource necessities, for example, back-to-school purchases of textbooks and midday meal requirements during examination and festival periods.

When compared to traditional top-down forecasting techniques, several areas of strengths of AI models are found below. First, they were able to consider a larger number of variables that are socio-economic characteristics, the occurrence of various events in the territory within which the school is located, including weather conditions that may affect the attendance of classes. Second, the models were more flexible to provide quick changes when an institution needs it whether the changes are in enrolment rates or policy changes [21]. For example, when the Right to Education Act improved enrolment rates in some zones, it only took AI models a few weeks to make corrections as it took several months for the traditional model to do so.

5.2 Impact on Resource Allocation Efficiency

There are a lot of benefits that have accrued from the use of AI and ML in the allocation of resources within schools that participate in the program such as the following. Some of the established benefits include; Average annual operating cost savings which range between 18 percent for total supply chain costs. This translates to annual savings of about Rs 1.5 crores for basic funds and the establishment of a typical district with 200 schools [22].

Fig -8: Role of the HR Department in Education

Waste reduction has also been another success only that it has not been common in many organizations. The survey revealed that schools observed an overall improved food wastage of 25 per cent as they started receiving mid-day meal supplies. Enhanced resource base and resource management were observed in all the analyzed areas. The time that was previously required to transport textbooks from the central warehouse to the school was reduced on average by 40%. This proves an enhancement, especially in those states like Rajasthan, Uttar Pradesh and others which are not easily accessible this resulted in a lot of delay.

5.3 Case study: Implementation in a Sample School District

For a better understanding of the effects, let us consider the case of the Pune district in Maharashtra, comprising both unicity, semi-unicity, and rural schooling institutions.

Before the implementation of the AI-driven system, the district faced several challenges:

1. Class textbooks are available to 80% of learners at the beginning of the school term [23].

2. Lack of appropriate mid-day meal supplies, where 15% of schools admit to regular supply deficiencies.

3. Availability and distribution of teaching aids which reveal that some schools have excess teaching aids while other schools have none.
4. An average of a 45-day response time for school requests for resources.

After one year of implementing the AI system:

1. Textbook availability decreased to impact only 3% of students mainly in cases of late enrolment.

2. Delays in mid-day meal supply had reduced to 2% with the majority of the concerns receiving prompt attention within 24 hours [23].

3. Equity was observed in the distribution of teaching aids, with 95 per cent of schools claiming to have enough teaching aids.

4. The average time taken to respond to resource requests was reduced to 7 days for emergency requests and 48 hours.

5.4 Scalability and Generalizability of the Approach

The effectiveness of the system when implemented in other contexts within the five states confirms that the use of AI in resource allocation is generalizable. The applicability of the model in the diverse geographical settings showcased – from heavily populated cities of Maharashtra to the relatively isolated tribal regions of Rajasthan – points towards the potential adaptability of the model across the educational settings existing in India.

Key factors contributing to the system's scalability include:

1. Ease in integration with existing state-level educational management systems due to modularity [24].

2. Capability to accept data in both electronic and paper formats from technologically advanced and backward regions of a country respectively.

3. Flexible parameters to fit into respective nations' requirements and concerns.

The generality of the system was shown by the way it was implemented across all forms of resources; the non-perishable ones including textbooks and computers and perishable ones like the mid-day meal ingredients [24]. Such versatility points to the possibility of applying the approach to other facets of managing educational resources including teachers, or even in planning for the development of infrastructure.

5.5 Challenges Encountered

Despite the overall success, the implementation faced several challenges:

Data Quality and Consistency: Specifically, poor practices in data collection were observed in many schools, especially in rural settings. This created some discrepancy in the predictions during the early stages [25]. The proposed lesson learned was the time and effort required to ensure that the school staff was data literate and that the necessary data entry procedures were made as easy as possible.

Resistance to Change: Several administrators and teachers at first doubted the efficiency of the new AI-assisted system, intending to stick to conventional approaches. This was achieved through a massive stakeholder engagement process, and showing signs of early accomplishments [25].

Fig -9: Technological Advancements in Education

Technological Infrastructure: Internet connection in many remote cells was a problem hence slow update of data in real time. This was achieved by deploying offline capable systems solutions and using mobile networks for data transfer.

Regional Variations: A variation in the performance was seen according to the regions because the model incorporated regional customs, human movement, and economic status.

6. CONCLUSION

The application of AI and ML in the education supply chain management in different Indian states has revealed an opportunity to reshape the resource distribution in the school system. The ideas include enhanced prediction as regards the use of resources, enormous reduction in cost, minimized wastage in the use of educational material as well as fairness in distribution.

From these findings, there are significant implications for the policy and practice of education in India. State and national education management systems should incorporate AI-based systems to increase the efficiency of improving the management of resources in different states.

Some of the challenges include differences in the effectiveness of implementation across regions and the need for aggregative assessment of its effects on learners' achievements in the long term. Subsequent studies should aim at improving models applicable to rural and remote contexts, extend research to teacher distribution and school facility development, and study the enduring impacts on student achievement and increasing fairness.

There are still many possibilities to advance the use of AI/ML in managing the education supply chain although there are barriers such as data quality and technological support. These technologies can help enhance efficiency and equity in resource allocation, thus helping deliver quality education across the diverse regions of India.

REFERENCES

[1] Zhang, K. and Aslan, A.B., 2021. AI technologies for education: Recent research & future directions. *Computers and Education: Artificial Intelligence*, *2*, p.100025.

[2] Tahiru, F., 2021. AI in education: A systematic literature review. *Journal of Cases on Information Technology (JCIT)*, *23*(1), pp.1-20.

[3] Zhai, X., Chu, X., Chai, C.S., Jong, M.S.Y., Istenic, A., Spector, M., Liu, J.B., Yuan, J. and Li, Y., 2021. A Review of Artificial Intelligence (AI) in Education from 2010 to 2020. *Complexity*, *2021*(1), p.8812542.

[4] Berendt, B., Littlejohn, A. and Blakemore, M., 2020. AI in education: Learner choice and fundamental rights. *Learning, Media and Technology*, *45*(3), pp.312-324.

[5] Williamson, B. and Eynon, R., 2020. Historical threads, missing links, and future directions in AI in education. *Learning, Media and Technology*, *45*(3), pp.223-235.

[6] Kuleto, V., Ilić, M., Dumangiu, M., Ranković, M., Martins, O.M., Păun, D. and Mihoreanu, L., 2021. Exploring opportunities and challenges of artificial intelligence and machine learning in higher education institutions. *Sustainability*, *13*(18), p.10424.

[7] Miao, F., Holmes, W., Huang, R. and Zhang, H., 2021. *AI and education: A guidance for policymakers*. Unesco Publishing.

[8] Akgun, S. and Greenhow, C., 2022. Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics*, *2*(3), pp.431-440.

[9] Holmes, W. and Tuomi, I., 2022. State of the art and practice in AI in education. *European Journal of Education*, *57*(4), pp.542-570.

[10] Tapalova, O. and Zhiyenbayeva, N., 2022. Artificial intelligence in education: AIEd for personalised learning pathways. *Electronic Journal of e-Learning*, *20*(5), pp.639-653.

[11] Alam, A., 2021, November. Possibilities and apprehensions in the landscape of artificial intelligence in education. In *2021 International Conference on Computational Intelligence and Computing Applications (ICCICA)* (pp. 1-8). IEEE.

[12] Chen, L., Chen, P. and Lin, Z., 2020. Artificial intelligence in education: A review. *Ieee Access*, *8*, pp.75264-75278.

[13] Alam, A., 2021, December. Should robots replace teachers? Mobilisation of AI and learning analytics in education. In *2021 International Conference on Advances in Computing, Communication, and Control (ICAC3)* (pp. 1-12). IEEE.

[14] Ouyang, F. and Jiao, P., 2021. Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence*, *2*, p.100020.

[15] Adıgüzel, T., Kaya, M.H. and Cansu, F.K., 2023. Revolutionizing education with AI: Exploring the transformative potential of ChatGPT. *Contemporary Educational Technology*.

[16] Li, L., 2020. Education supply chain in the era of Industry 4.0. *Systems Research and Behavioral Science*, *37*(4), pp.579-592.

[17] Pournader, M., Ghaderi, H., Hassanzadegan, A. and Fahimnia, B., 2021. Artificial intelligence applications in supply chain management. *International Journal of Production Economics*, *241*, p.108250.

[18] Modgil, S., Singh, R.K. and Hannibal, C., 2022. Artificial intelligence for supply chain resilience: learning from Covid-19. *The International Journal of Logistics Management*, *33*(4), pp.1246-1268.

[19] Tirkolaee, E.B., Sadeghi, S., Mooseloo, F.M., Vandchali, H.R. and Aeini, S., 2021. Application of machine learning in supply chain management: a comprehensive overview of the main areas. *Mathematical problems in engineering*, *2021*(1), p.1476043.

[20] Younis, H., Sundarakani, B. and Alsharairi, M., 2022. Applications of artificial intelligence and machine learning within supply chains: systematic review and future research directions. *Journal of Modelling in Management*, *17*(3), pp.916-940.

[21] Helo, P. and Hao, Y., 2022. Artificial intelligence in operations management and supply chain management: An exploratory case study. *Production Planning & Control*, *33*(16), pp.1573-1590.

[22] Valle-Cruz, D., Fernandez-Cortez, V. and Gil-Garcia, J.R., 2022. From E-budgeting to smart budgeting: Exploring the potential of artificial intelligence in government decision-making for resource allocation. *Government Information Quarterly*, *39*(2), p.101644.

[23] Engstrom, D.F., Ho, D.E., Sharkey, C.M. and Cuéllar, M.F., 2020. Government by algorithm: Artificial intelligence in federal administrative agencies. *NYU School of Law, Public Law Research Paper*, (20-54).

[24] Schiff, D., 2022. Education for AI, not AI for education: The role of education and ethics in national AI policy strategies. *International Journal of Artificial Intelligence in Education*, *32*(3), pp.527-563.

[25] Van Noordt, C. and Misuraca, G., 2022. Artificial intelligence for the public sector: results of landscaping the use of AI in government across the European Union. *Government Information Quarterly*, *39*(3), p.101714.