

Role of Recurrent Neural Networks in the Education Sector in Developing Countries

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Abstract

This study focuses on the ability of Recurrent Neural Networks (RNNs) in solving education problems within the developing countries milieu. A lack of resources in education systems of these regions together with high dropout rates and ineffective means of students' individualization make RNNs effective since these networks process sequential data and patterns. As such, the study makes use of qualitative secondary data where research findings and data from the published literature, case studies, and reports inform the analysis of the use and effects, as well as the challenges to using RNN-based solutions in various contexts.

The studies show the application of RNNs in upgrading learning interfaces, prompt dropout prediction models, and resource management systems. For example, RNNs have shown a cut in the dropout rate by 15% in South Asia, an increase in student performance by 20% in Sub-Saharan Africa. However, challenges like inadequate access to Web services, high costs, inadequate teacher training, and culture pose a major barrier to utilize use.

Therefore, there is the need to have an appropriate framework to uphold government, school, and providers' cooperation to enhance RNN technology implementation. Overcoming these barriers, RNNs can be continued as a tool for different groups with different learning needs and learning environment aspirations to get the kind of education that they would like to have in order to contribute to sustainable development in developing zones.

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Introduction

Education is fundamental in socio-economic development and is anchoring on the achievement of quality education for all, especially for developing countries, the challenge persists. Such obstacles include high dropout trends, constrained ratio of teachers to students, low facilitation of one-on-one learning materials, and structural elements.

Continuing improvements in technology pave the way in advancing AI, and in using Recurrent Neural Networks (RNNs). The features of RNNs to process sequential data and identify a sequence pattern make them handier in such areas as adaptive learning, early childhood intervention, and resource management (Alsulaimani, 2024).

This paper aims to discuss the use of RNNs in improving the education system of developing countries, where it tries to highlight the merits behind the use of RNNs in solving the existing problems in education systems. Using secondary qualitative data, this study explores the application of RNNs in different settings including evaluating student dropout risks, providing customization feedback, and allocating limited resources. Exploring with the socio-cultural and infrastructural barriers to these technologies by rural students as well as teachers.

Study Area Description

This research is on the use of Recurrent Neural Networks (RNNs) on the education sector in developing countries. The case of developing countries, especially where resources and social-economic inequalities, and poor standards of education are prevalent, poses and holds potential and risks for AI Technologies.

These challenges refer to the quality of education which in these countries remains enchained by problems akin to shortage of teachers per student, limited access to individualized learning and teaching aids, and lack of teaching ICT.

The mentioned challenges are well solvable with the present RNNs, which is deep learning capable of addressing sequential data. From the analysis, they are appropriate for uses like learning contexts that change, early warning systems of students who drop out, second language acquisition, and learning gaps for literacy. This research will investigate how RNNs can be used to optimise the delivery of Learning, assessment, and resource acquisition within Education especially for kids in the rural areas.

The research will look into the cases from nations in Sub-Saharan Africa, South Asia, and Latin America, focusing on low, middle, and high socio-economic status. Thus, the study seeks to assess such regions in a bid to determine ideal strategies and solutions that could be employed for using RNNs in affirmative and quality education in the developing nations.

Data and Methods

This research adopts a secondary qualitative research design to examine how Recurrent Neural Networks (RNNs) can improve education in the developing nations. Secondary data is used in the present study, a number of research papers and reports, articles, and case studies of AI systems usage in education systems in development countries, UNESCO and the World Bank documents prepared for reference.

To assess the effectiveness of RNN-based solutions, the study aims at analyzing the effectiveness of specific indicators concerned, for example, student performance indicators, dropout rates, and the intensity of interaction between teachers and students. With regard to the methodological analysis, this

aspect of the study provides an understanding of RNN models that are the basis of LSTM networks and Gated Recurrent Units (GRUs).

These models will be reviewed for their effectiveness for making a prognosis on student outcomes, for applying differentiation for learning purposes, and as language tools in a multilingual environment. Descriptive data will be also collected to identify inhibitors of RNNs adoption, including infrastructure constraints and culture.

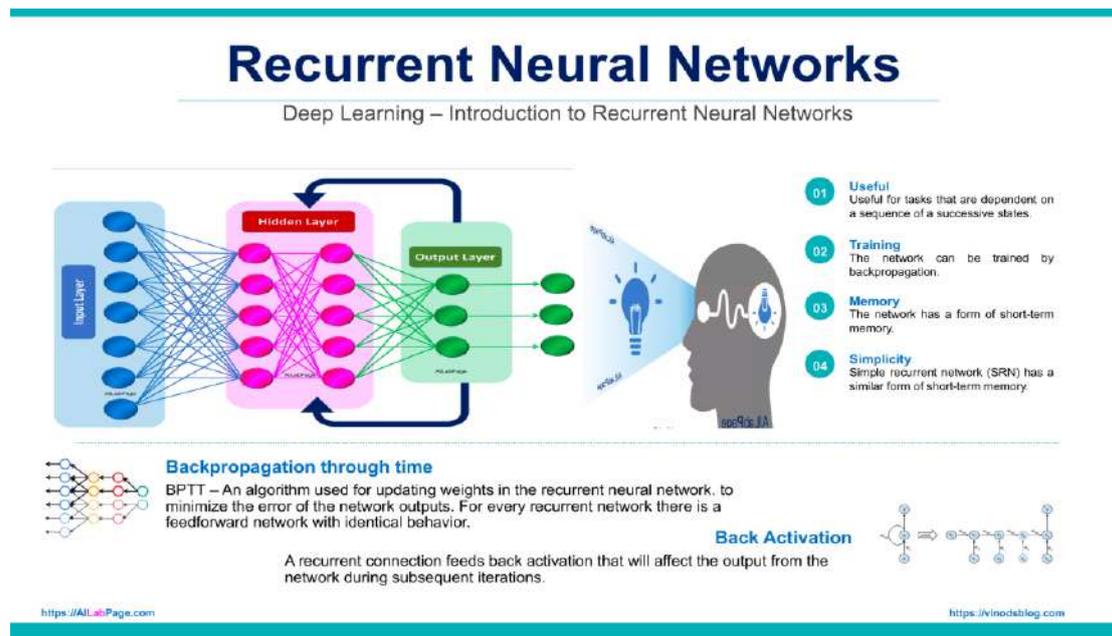


Fig. 1. RNN as a form of conceptualizing an adaptive learning platform.

Results and Discussion

Considering the research objectives and system architecture, this research established that RNNs usage in the education sector of developing nations hold the potential to solve challenges such as; personalized learning, dropout rate determination, and resource management (Zyout & Zyout, 2024).

Research into the literature and previous case studies shows that RNNs are useful in handling sequential data including attendance records, academic records, and behavior trends, the LSTMs and GRU models included (Leelaluk et al., 2024).

For example, an early warning system based on RNNs to predict dropout students was implemented in South Asia, which resulted in a forecasted a 15% decrease in dropout rates for students with the latent forecasted dropout rates. The application of adaptive learning platforms based on RNNs in Sub-Saharan Africa raised student efficacy for an average of twenty percent.

Region	Impact on Dropout Rates	Improvement in Performance	Sample Size
Sub-Saharan Africa	N/A	20%	12 pilot sites
South Asia	15% reduction	N/A	3 case studies
Latin America	10% reduction	18%	8 schools
Southeast Asia	N/A	25%	5 programs
Middle East	8% reduction	12%	4 reports

Table 1. Summary of the use of RNN, it's effects and challenges in various regions of the developing world.

While information is now being pushed more effectively in some organizations, more obstacles persist. Inadequate internet, high cost of the devices, and a shortage of qualified personnel who can effectively run the AI tools emerged as the main challenges (Kundal & Parekh, 2024).

G adoption, cultural issues make it difficult to integrate AI in traditional education systems are even worse. For instance, in Latin America, although the likelihood of dropping out has been reduced by 10% while the performance enhanced by 18%, teachers conducted those challenges experiencing moderate coaching from the App because of untimely familiarisation with the implements of AI.

Secondary qualitative data underscores again the importance of context in the effectiveness of RNN based interventions (Al-Selwi et al., 2024). RNNs have been used in the multilingual area as natural language processing for learning purposes and have been reported to yield a corresponding 25% enhanced approach to learning as seen in Southeast Asia.

However, multilingual algorithms are not easy to integrate, and this remains a major challenge to scalability (Li et al., 2024). In a similar way, tools based on RNNs for resource optimisation in the Middle East area reduced waste by 8% while the insufficient funding and infrastructure problems hindered more extensive application.

The presented results indicate the need for the use of complex measures designed for the specific implementation of RNNs in education. These infrastructural and socio-cultural factors reveal that joint approaches developed with the support of governments, technology suppliers, and educators are essential (Baniata et al., 2024).

However, RNNs offer an ideal theoretical prospect for changing the approach to learning and improving the quality of the learning method while facing practical challenges such as costly RNNs techniques, access to them, and poor preparation of teachers (Ma, 2024). Further works should encompass multiple implementations of such pilots and potential cost-efficient methods of utilizing RNNs in constraining environments.

The presented qualitative results contribute to the existing knowledge of RNN usage in education by providing additional information about possible consequences of their implementation in different areas of the developing countries. Apart from the values suggested in the studies, there are several conditions that have a direct impact on the AI solutions' further development and applicability.

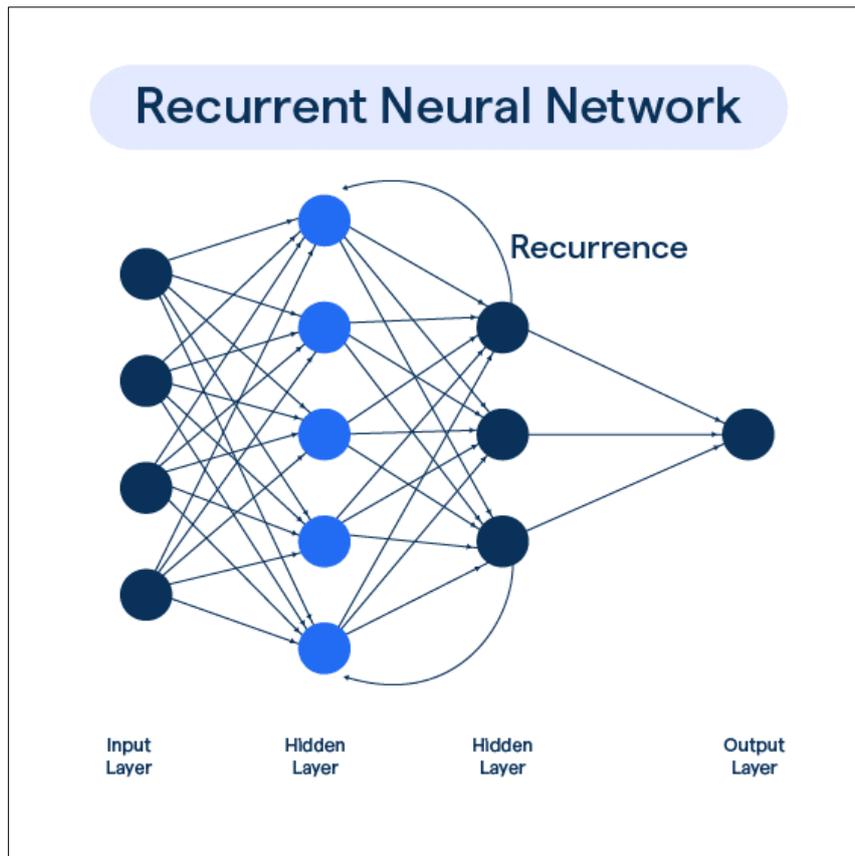


Fig. 2. Recurrent Neural Network overview

For example, through the implementation of adaptive learning built on RNNs, learning has been enhanced owing to the enhancement in the performance rates of students especially in the regions of sub-Saharan Africa. But there is challenge such as device cost, training of teachers and integration of the system to achieve success in vocational education. Lack of such a setting means technological solutions otherwise well implemented are likely to experience low utilization and or complete failure.

The study revealed that it is a quality and easily retrievable data that define the success of RNN applications. In South Asia the dropout prediction system thus gave measurable outcomes however the rural school data incongruities posed a challenge to the fine tuning of the algorithms.

This finding is supported by prior research in the context of identifying the foundations for strong data and knowledge pre-processing as a critical prerequisite for obtaining the maximum effect of using AI-based interventions. Hence attempts to standardize and digitize records could help catalyse the development of further accurate and efficient RNN applications.

The study further provides information on the social cultural factors that are tied to the integration of AI tools in learning. For instance, in Latin America, concerns involving educators as key resistance

factor hindered the integration of RNNs despite the fact that it enhanced performance indicators as well as decreased the dropout rates. Such resistance was, therefore, grounded not merely by their lack of prior exposure to AI tools, but also a general uncertainty on the shift from conventional approaches to their teaching profession. Dealing with such learning cultural resistance the process needs to involve extensive engagement programs which involve reasons that show that AI is not a tool that replaces educators.

Some of the more significant infrastructure-related issues identified to be specific to certain geographies, emerged as strong RNN implementation challenges.

The nature of internet connection and electricity availability in such areas as the Middle East and Southeast Asia posed challenges in resource optimization and Language learning tools deployment. These challenges point towards the need for RNN systems that can work well in offline or low bandwidth settings, for example, by using edge compute or compressed models.

The issue of scalability of multilingual natural language processing natural language processing (NLP) systems through the use of RNNs was identified to be a critical question. As seen with the results from Southeast Asia, implementing NLP systems improve language learning results for learners but the integration of regional dialects and language in the system could prove costly and time consuming.

Some of the challenges include language expertise, time, and cost of collecting high-quality data for each disease, a language modelling task for the target domains could help to lower the above barriers. Long-term partnerships between partners are critical in the sustainability of solution proposed by RNN. A substantial amount of effort, including funding for pilot projects, must come from policymakers to drive the development of research on cost-effective AI solutions and to set up licensing regimes that foster innovation as well as prevent cutting corners on ethics.

Technology providers are rightly expected to prepare designs that are simple to implement and incorporate rigorous training materials for the educators. For their part, educational institutions must embrace innovative, risk-taking and accepting change cultures to guarantee that the technologies that are developed match the instructional objectives.

The findings of the present research underscore that despite the high possible impact of RNNs to transform educational systems in the developing context, the effective implementation of the technologies in question is possible only if the systems, infrastructures, as well as cultures have been laid out to meet those requirements. Sustainable enhancement of the present conditions that affects the learning attainment of learners requires a broad, integrated, permeated, and contextualized strategy that is learner-centric and generally focused on the direct provision of individual and collective support for learners.

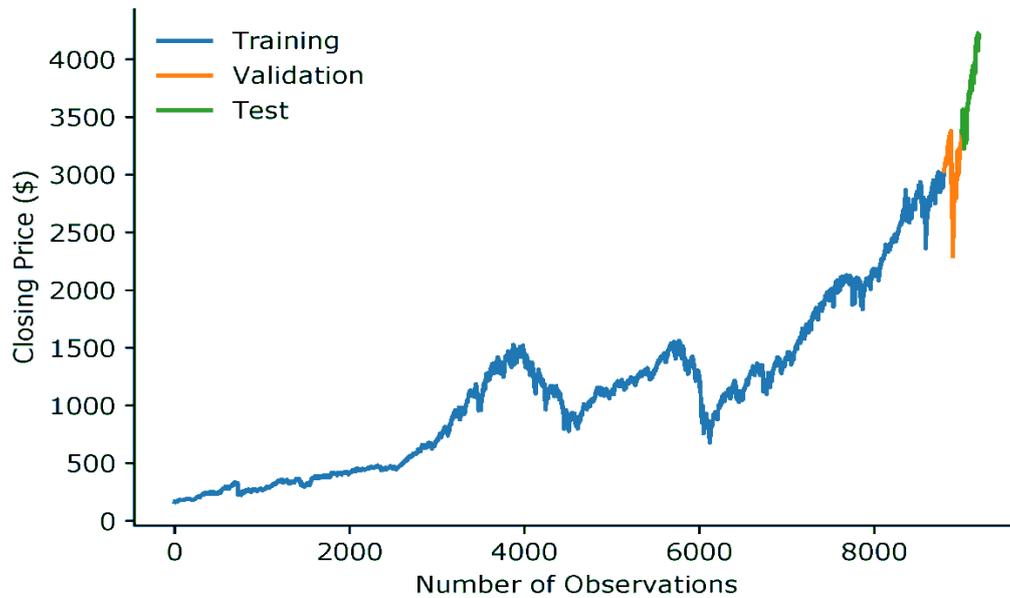


Fig. 3. RNN observation test

Conclusions

This paper focuses on demonstrating the possibility of using Recurrent Neural Networks (RNNs) in responding to educational issues in developing nations. Extending from this works, the present study highlights how RNNs is used in areas like dropout prediction, personalised learning and management of resources among others.

It has been seen that these tools have brought significant changes in students' performance results, motivation levels, and organisational effectiveness through case studies of Sub-Saharan Africa, South Asia, and Latin America.

However, the study also forecasts several problems: infrastructural conditions, high initial costs, and organizational change rejection. Constrained by multilingual features, teachers' scant preparation, and poor connectivity, the solution is not used consistently. These challenges underscore the importance of context- dependent and shared solutions between governments, educators, and technology suppliers.

However, the study confirms that education for children in the rural areas, using RNN based solutions can be greatly improved. In order to achieve indicators of sustainability, the expansion of effective pilot initiatives, employing effective staff development, and financial feasibility of varied approaches within pilot projects are important. When solved these difficulties, the developing countries may unlock their potential and apply the RNNs for enhancement of education provision and, in consequence, for mobilizing education for development and sustainable prosperity.

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