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Agile neural expert system for managing basic education

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ABSTRACT

Inadequate experts in managing resources at the lower level of education to enhance effective teaching and learning for quality education is a significant challenge in developing nations. Many basic schools lack basic educational resources such as sitting places and writing places for learners. Inadequate teaching and learning resources negatively affect the educational policies in a country. It is common to see the media projecting the challenges of a school lacking these resources. The use of an Expert System (ES) in Artificial Intelligence (AI) to assist in effective management is a necessity. In this paper, an agile neural expert system is proposed using differential equations with an initial value problem. The technique combines both rule-based and neural networks in handling the problem. The expertise of the Human Expert (HE) is used in a knowledge-based to assist in managing the resources in schools. This has been possible with the use of Data Mining (DM) techniques and modeling of projected population growth, affecting enrolment in schools and necessitating the provision of resources to cater to the growing population. For efficiency and effectiveness in planning, provision, and management of the resources, smart notification has been embedded in the system to monitor the availability and provision of the resources by prompting the various actors in the requisition, verification, validation, and approval of resources to be supplied to schools. The system proves a higher efficiency demonstrating speed in decision-making, accuracy in decisions and ease to use.

1. Introduction

Education in a country affects the economic sectors of the country. The preparation of the labor force of a country strongly depends on the system of education in place. A chunk of budgetary allocations in countries goes to Education and basic education takes the higher percentage of the expenditure (MOE, 2018). Basic education specifically refers to the lower levels of education which serve as the core or foundation for education in a country. In Ghana, it refers to the levels with expected school-going ages from 4 years to 14 years. The administration of education in terms of resource provision and utilization is a challenge in basic schools in Ghana. Some managers of educational institutions do not have the expertise to manage educational resources. This calls for a system to mimic the expertise of an expert to assist in effective decision-making. The use of mathematical and graphical models in Expert Systems to represent the real-life situation in schools to trace and predict resources availability, provision and utilization will help in building a robust system for effective resource management. Several research works including (Sifuna et al., 2009) and (Zwane & Malale, 2018) acknowledge the negative effect of inadequate resources on effective teaching and learning. This paper proposes a novel means of tracing the challenges of education to provide adequate teaching and learning resources for this group of learners to enhance inclusivity and equity. To the best of our ability, this is the first system proposed in this direction hence the use of the initial value problems in differential equations. The nuisance of inadequate teaching and learning resources is a significant factor that affects quality teaching and learning in schools. Both sharable and non-sharable educational resources are not adequate in schools in developing nations, especially in rural areas. Careful planning and proper control of the allocation of resources are a necessity to enable in management of educational resources. As indicated in Inusah, Missah, Ussiph and Twum (2021),(Inusah, Missah, Najim & Twum, 2022) and (MOE, 2018) inaccuracies in data management strongly affect the efficiency of decision-making which curtails the effective provision and allocation of teaching and learning resources. The consequence is the exclusion of some learners as well as dropouts in school. In Supriyanto, Widiaty, Abdullah and Mupita (2018), utilizing ICT can help in improving the quality of education in a country. This is

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more effective when the expertise of the HE is computerized to help in solving problems in the field of education. Elimination of errors and personal interest will help in enhancing efficiency in decision-making for effective implementation (Inusah & Amponsah, 2018). From the paper (Gaber & Fahim, 2018), administrative decisions can be improved through ES by mimicking the expertise of the HE. The business effectiveness of information technology investment can be measured through ES (Mavaahebi & Nagasaka, 2013).

The importance of ES in education is realized in the paper (Khanna et al., n.d.). Educational indicators for measuring performance such as enrolment, learning attainments, demographic attributes of learners and the effects on their performance, etc. are proposed in an ES to enhance effective decision-making in education. The relevance of using ES as addressed by Academy and Academy (2011), clearly looks at strategic management as an aspect of management that is challenging to be replaced by ES but can be assisted in the form of a decision support system for effective management. Both external and internal critical factors in decision-making can be considered. With the advent of AI, blending ES with data mining or machine learning is a more efficient means. Predictions for future occurrences and the resources needed can accurately be made. A paper (Mavaahebi & Nagasaka, 2013) looked at neural networks and ES in measuring the effectiveness of information technology investment. Various returns on investments and other indicators in measuring the performance of a business are properly dealt with. A related paper,(Nadali, Kakhky & Nosratabadi, 2011), used the Cross-Industry Standard Process (CRISP) to evaluate the success level of data mining projects using a fuzzy ES. As educational institutions are perceived as investments for the future of learners, adequate resource provision is a necessity for a better outcome. The goal of this work is to propose a novel model to enhance the effective management of educational resources in schools for quality education for the growing population. Specifically, the system will help in knowing the available resources in schools, determine the deficit for the growing population and also ensure the faster provision of resources to schools through a smart notification system.

This work is organized into six areas; the first part is the introduction which draws readers' attention to the nature of the problem. The second part is the related works which try to review the literature on already existing works which are of relevance to the problem. The third part is the methodology used in addressing the problem. Here, an agile neural expert system is used in addressing the problem with differential equations to formulate and validate a model for the population growth which affects enrolment and the provision of resources. The use of data mining in the system to address the challenges of education is also presented. The fourth part is the evaluation of the model by using real-life data to do testing. The fifth part is the results and discussions. The sixth part which is the final part is the conclusions drawn from the work.

2. Related work

In (Dietzmann, n.d.), managerial information and decision-making in big data have been analyzed using AI. Structured and unstructured decisions are made by managers for the effective running of businesses. These decisions are made from higher volumes of data realized from the operations of an organization. Various themes in the decision-making process are considered to know the nature of decisions and how such decisions affect the progress of organizations. The paper (Jarrahi, 2018), looks at the strengths and weaknesses of AI, and the HE has carefully been looked at. Complementing these two aspects in decision-making will help in dealing with complex computational data that is needed in projections in decision-making. In a related paper, (Parry, Cohen & Bhattacharya, 2016), the use of AI in place of HE especially in group risky decisions has been acknowledged. A prediction of the replacement of the HE by AI in the near future is made. In a review by Duan, Edwards and Dwivedi (2019), the paper looks at AI for decision-making in general and the possible replacement of the human expert in decision-making by revitalized based ESs. Conclusions on the efficiency of decision-making using AI reveal a higher efficiency than human decision-making. Senior management decisions which are usually strategic can be achieved through AI (Hawaii International Conference on System Sciences, 2020., n.d.). AI can be applied in varied fields of study to enhance the effective and efficient utilization of resources (Roetzel, 2019).

ES is a significant aspect of AI that looks at how to mimic the expertise of the domain expert in a repository called the knowledge-based to assist non-experts in practicing with the expert's knowledge (Haenlein & Kaplan, 2019; Inusah & Amponsah, 2018). In (Gaber & Fahim, 2018), areas of ES regarding decision support in business for various tasks have been looked at. It was realized that the use of ES can help in improving decision-making in the organization and also maintain competitive strength through quality management. Judging from the research, the implementation of the findings dwells much on the willingness and readiness of organizations to use ESs in decision-making. This is however a challenge since most public institutions have a lukewarm attitude towards the use of technology. The paper (Mavaahebi & Nagasaka, 2013) used Neural Networks and ES-based models to measure the business effectiveness of Information Technology investment. This was a new method named Artificial Neural Networks ES IT Effectiveness Calculation. The method explored already existing ESs to identify the weakness and build on the strengths. Key Performance Indicators in business such as Return on Investment (ROI), Net Present Value (NPV), etc. are used in determining the success or failure of an organization using Neural network techniques in data mining. This model allows comparison of past business operations, calculations of key Indicators, what-if analysis functionalities, making projections, etc. The strength of this research dwells much on the use of neural networks through data mining techniques since it can learn to adapt to different situations. This makes it possible for flexibility of usage in other organizations with similar features of challenges. However, the "black box" nature of neural networks makes it difficult for the domain expert to understand how the system works. This may forfeit the purpose of ES since the HE cannot build the system by adding their knowledge. The application of ES in the field of education is limited to teaching and learning at higher levels of education. Lower levels of education, as well as resource provision and availability, have been relegated by AI experts, especially in ES. Also, blending ESs with data mining techniques is a necessity to help in improving the decision-making process.

Data mining with ESs is a novelty in AI that enhances efficiency in solving related managerial problems using a trend of data for prediction with accuracy. This novelty not only makes it easy and faster but also enhances more accuracy of decision-making. In (Machine Learning & Cybernetics, 2008 *International Conference On.*, 2008) ES and data mining techniques using the rule-based technique are proposed for managing data. This is a modification of the apriori algorithm. It caters to ratiocination as a major target in ES as well as the value relationship between data items in data mining. The paper (de Groof et al., 2020) looks at deep learning in a computer-aided ES. A higher level of accuracy and validity with benchmarks is recorded with this integration of techniques. In a related paper (Anbuselvi & Tech, 2021) a recommendation system with the same technique of deep learning is used in the finance model for firms to handle the financial investment. This has helped in managing finance well to eliminate the challenges of managers running and making frequent calls to handle business-related problems. In (Lu, Tung & Wang, 2021) maintained ES for diagnosis using association rules rather than the rule base which is inefficient for handling such a task. The rules-based is good for already existing data whiles the association rules are good for real-time data and behavioural pattern identity. Financial restatement detection using data mining techniques to enhance accuracy for regulators and investor is also another paper (Dutta, Dutta & Raahemi, 2017). The use of ES with data mining techniques in education is, therefore, necessary to solve management-related problems.

The application of ES in education can be seen in (Supriyanto et al., 2018). Quality education as a foundation for success in education is carefully monitored in this paper. Literature from various countries with ESs in education has been looked at. The findings revealed a diverse area in the application of ES. In a survey by (Hoda et al., n.d.), the use of ES in many areas of study such as health, education, automobile, agriculture, etc. has been reviewed in a survey. It was revealed that ESs are ordinarily in very limited areas. Other aspects of study need to adopt this novel technology to enable easy preservation of the knowledge of the domain expert and decision-making. This can best be done when it is integrated with data mining techniques. In (Kaur, Agrawal, Singh & Jain, 2014), a fuzzy-based ES which uses data mining techniques is used in monitoring the performance of students. This takes into consideration the various attributes of learners which strongly affect students' performance. The role of corporate planning and expert handling can be seen in (Modernising-School-Governance-2016, n.d.) timely planning and accurate interventions in expert decision-making can assist in efficiently managing educational resources. This is relatively easier when educational ES built with data mining techniques is applied in management. It is prudent in the literature available that, the use of data mining techniques with ESs is the most efficient means of handling management and decision-related task. This is the basis or justification for the blending of data mining techniques in the ES to assist in the educational management of resources in schools to enhance quality education.

2.1. Neural expert systems applications

The application of neural networks in expert systems applications has relevance in solving problems with real data. In (Martínez-Martínez, Gomez-Gil, Gomez-Gil & Ruiz-Gonzalez, 2015) genetic algorithm is used in a neural expert system to detect the status of rotary components in the agro-industry. Fuzzy clustering complex-valued neural network is used in (Ceylan, Ceylan, Özbay & Kara, 2011)to diagnose cirrhosis disease. A hybrid decision-making artificial neural network is used for the conditioned assessment of bridges in the paper (Fabianowski, Jakiel & Stemplewski, 2021). In (Severino & Peng, 2021), fraud prediction in property insurance using a machine learning algorithm with real-world microdata is presented. The strengths and weaknesses of the model are proven with the help of risk analysis and professional assessment.

Specifically, in education, the neural expert system has played a major role. A genetic algorithm neural network is used in the prediction of chines children having dyslexia in development(Wang & Bi, 2022). In musical education, the sensing and hearing of the instruments can be measured using a neural expert system(Özelik & Hardala, 2011). In (Setiawan, Yahya, Chun & Lee, 2022) human action recognition with a skeleton-based neural network using a convolution graph. This can be applied in basic education to assist in identifying the challenges and getting sustainable solutions to reduce the cost of managing basic schools in Ghana as a country and the world as a whole.

2.2. Rule-Based expert systems

Rule-based expert systems are the commonest among expert system applications. In (Zisad, Chowdhury, Hossain, Islam & Andersson, 2021a), Visual sentiment analysis under uncertainty is presented with the rule-based expert system in integrated deep learning. Web-based belief rule-based expert system for predicting floods is presented in (Ul Islam, Andersson & Hossain, 2015a). In the paper (Eastern Washington University et al., n.d.) innovative capability of high-tech firms is evaluated using a rule-based expert system. Belief rule-based expert system is also applied by (Andersson, Hossain, Thapa & Zander, 2016) where a novel framework is integrated to evaluate electronic government services using expert systems. In (Zisad, Chowdhury, Hossain, Islam & Andersson, 2021b) the same belief rule-based expert system is used for visual sentiment analysis. The prediction of the flood is also presented in a web-based belief expert system (Ul Islam, Andersson & Hossain, 2015b)

2.3. Importance of the proposed system

The importance of the ES in managing Basic Education is seen in the responses of the various stakeholders of education. Table 1 presents previous research works.

Getting a centralized system for gathering and sharing educational information will help in minimizing the cost, time, and errors in managing educational data. Also, having electronic data management as well as a source of reference to decisions made will assist in future decisions as precedence has been set. The efficiency of educational management will improve and the paper system will be eliminated. Speed in decision-making, the accuracy of decisions, and easy decision-making will be achieved in the proposed system. This will help in knowing every public basic school and its associated challenges to reduce the nerve-wracking challenges of basic education in Ghana which previous works have failed to do. Table 1 is a presentation of previous attempted research to identify and address the challenges of education in Ghana.

3. Methodology

Agile methodology is used in the development of the proposed system for managing the problem. The system is a neural expert system where both the rule-based and neural networks are combined in building the system. Rules on the decisions to be made regarding the challenges of a school are based on the enrolment of the school as well as the locality of the school. The Ghana Statical Service refers to a community with a population of less than 5000 as rural and more than 5000 as urban. Technically, if the enrolment of a school is more than the available resources for effective teaching and learning, the school is seen as deprived else, it is endowed. Educational resources are grouped into

Table 1
Research works in Basic Education in Ghana.

S/N	Authors	Year	Topic/Aspect	Research Techniques used
1	(Abukari, Kuyini & Mohammed, 2015)	2015	Examining the prospects and challenges of recent provisions	Purposive target interventions
2	(Mereku, 2019)	2019	Success, challenges and way forward	Survey analysis in graphs and tables
3	(Ampiah, Kwaah & Yiboe, 2007)	2007	Prospects and Challenges of the School Performance Improvement Plan	Percentages, charts and graphs
4	(Ametepee & Anastasiou, 2015)	2015	Special and inclusive education in Ghana: Status and progress, challenges and implications	Case study
5	(Akyeampong & Hunt, 2016)	2016	Access to Basic Education in Ghana: The Evidence and the Issues	Case study
6	(June 2018)	2018	Basic Statistics and Planning Parameters for Basic Education in Ghana	Charts, graphs and percentages.
7	(Aheto-Tsegah, 2011)	2011	Education in Ghana – status and challenges	Charts, percentages and tables
8	(Inusah et al., 2021)	2021	Enhancing Efficiency in Basic Educational Management using Data Mining Techniques	Classification and clustering
9	(Asare & Osei-Kuffour, 2021)	2021	Strengthening basic education in Ghana.	Reporting

sharable and non-sharable. The former refers to the resources that can be used by a group of learners during teaching and learning. The latter refers to the resources that can only be used by an individual user during teaching and learning.

3.1. Rules

R1: If population<5000, school is rural
R2: If population ≥ 5000, School is urban
R3: If school is rural and enrolment< resources, school is rural endowed
R4: If school is rural and enrolment ≥ resources, school is rural deprived
R5: If school is urban and enrolment ≤ resources, school is urban endowed
R6: If school is urban and enrolment > resources, school is urban deprived.

3.2. Challenges of education

C1: inadequate infrastructure
C2: inadequate sitting places
C3: Inadequate writing places
C4: Inadequate teachers
C5: Inadequate curriculum materials.
C6: poor maintenance culture

3.3. Proposed solutions

S1: Increase school infrastructure
S2: increasing the number of sitting places for learners
S3: Increasing the number of writing places for learners
S4: recruiting more teachers to the teaching service
S5: digitization of curriculum materials for schools with access to ICT
S6: instituting policies on the maintenance of public resources

In Fig. 1, the system has three layers; the input layer, the hidden layer and the output layer. The input layer is the schools and their data which gives the appropriate description. schools (SCH) are either in urban(U) communities or rural(R) communities. This is the application of R1 and R2 in the rule-based inference which constitute the two major classes. Rural schools are either deprived of resources or endowed with resources (RD and RE). Urban schools are also either deprived or endowed (UD and UE). The hidden layer is the applications of R3, R4, R5 and R6 in the inference to identify the challenges and subsequently get a solution. Each of the four categories is prone to challenges (C1, C2, C3, C4, C5 and C6) in education regarding resource availability. For each of the challenges, there is a corresponding solution S1, S2, S3, S4, S5 and S6. If these solutions are provided to the challenges of schools in the communities, deprived schools will be eliminated and all rural schools will be endowed (RE) and urban schools also endowed (UE). This will lead to quality education in the country which is the output layer.

Presented in Fig. 2 is the Expert System structure. Both the domain expert and the knowledge engineer are to blend their expertise in developing the system. As expert systems are designed to assist non-experts in decision-making, non-technical tools are preferred to be used in the design to enable domain experts who are not computing experts to contribute to building the system. Technically, two separate interfaces are available in this system; the expert interface and the user interface. The former will help in managing the system at the backend to enhance efficiency. The latter will also help the non-expert to interact with the system with ease.

3.4. Smart intelligent decision-making system

The algorithm for the decision-Making of the expert system is made smart with embedded messaging to notify users of the system in completing a request. Educational institutions in Ghana are uniquely identified with their EMIS codes in the data. This unique code identifies a school with its characteristics. The data of the school regarding the availability of resources are captured in the EMIS data. All the educational resources and their total number available are linked to the system automatically to enhance interoperability. The projected enrolment of a school at any point in time is compared to the available resources to know the status of the school. Schools in localities with less than 5000 people are seen as rural schools else they are urban. The difference

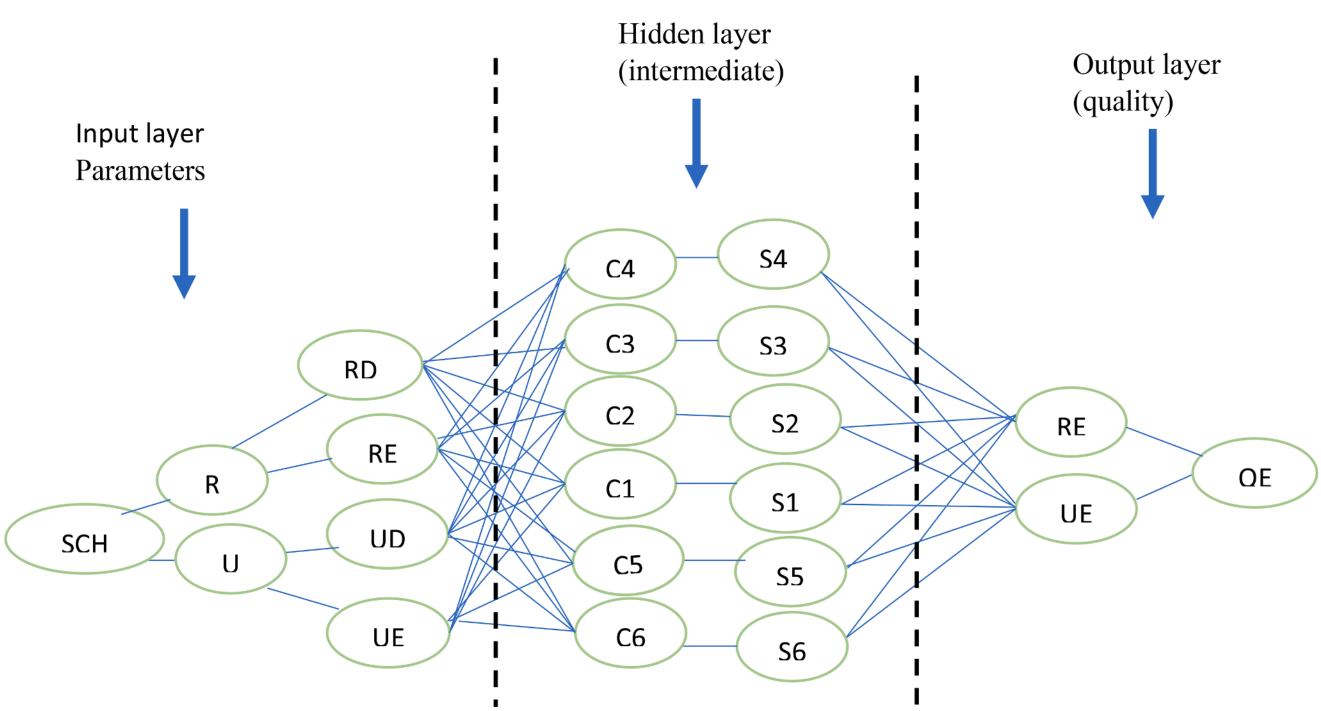

Fig. 1. Neural Expert System Model Structure.

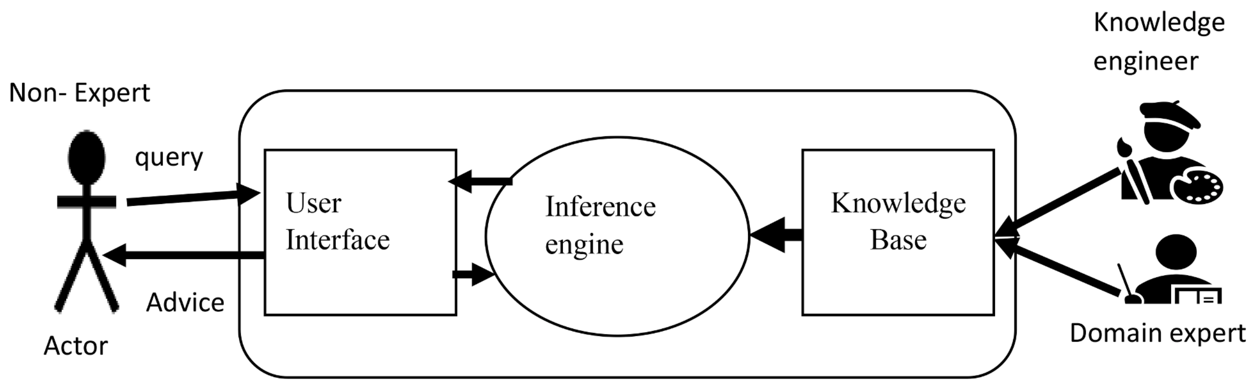

Fig. 2. Expert System Structure.

between the projected enrolment and the total available resources is requested to be provided. This is for resources that are non-shareable such as sitting places and writing places. For the shareable resource, as indicated in (MoE, 2018)the ideal number of basic school learners to share a resource is 40. This means the projected enrolment is divided by 40 and the results then compare to the available resources of such category. Selected fields in the EMIS database which contain information relevant for the decision making are; EMIS_Code which is the numeric unique code for every school or educational institution, Edu_Res which is a string variable for the educational resources, Total_Num_Res which is numeric for the total number of resources in an institution, Enrolment which is numeric and contains the total number of learners, and Loc_Pop which is also numeric for the population of the locality of the school. This is seen in Fig. 3. In the algorithm, an SQL select statement with a while loop is used to sort institutions into their various categories.

Algorithm: Smart Expert System

```
SELECT Emis_Code, Edu_Res, Total_Num_Res, Enrolment, Loc_Pop FROM EMIS;
Input: Enter EMIS Code of your institution
Output: CREATE VIEW Challenges AS
SELECT EMIS_Code, Total_Num_Res, Enrolment, Loc_Pop,
    FROM EMIS
WHERE Total_Num_Res<Enrolment
        WHILE
BEGIN LocPop<5000
            Print 'Your institution is rural deprived in" Edu_Res
            Print 'You need' Enrolment-Total_Num Res 'of Edu_Res 'more'
            Else
            Print 'Your institution is urban Deprived in' Edu_Res
            Print 'You need ' Enrolment-Total_num_Res ' of " Edu_Res more
        End if.
```

(continued on next column)

(continued)

Algorithm: Smart Expert System

```
        End
End procedure.
```

3.4. Population

In a population of every community, there exists a population of basic school-going age. Some of these populations are enrolled in schools. These enrolled pupils possess or use resources for effective teaching and learning to enhance quality education.

Let the population of the community (district, locality or country) be **c**, the population of basic school-going age be **b**, enrolment of pupils in school be **e** and the resources used be **r**

$$\Rightarrow \forall c \exists b, P(c) \Rightarrow \forall b \exists e, P(b) \Rightarrow \forall e \exists r, P(e)$$

Prove by contradiction (some enrolled learners do not have resources)

$$\Rightarrow \neg \forall e \exists r, P(e) \equiv (\exists e \notin r)(\neg p(e))$$

The population of school-going ages rises as the population rises. The enrolment of learners which also depends on the population also rises. The enrolment of pupils depends on this population of school-going age. If the population rises, enrolment also rises. The provision of educational resources also depends on the enrolment of pupils in schools. Predicting resource provision, the enrolment should be used. The higher the enrolment, the higher the provision of resources and vice versa. The quality of education depends on the availability of educational resources

EMIS_Code	Name_institution	Location	CountRes	LevType	Loc_Pop	Total_Num_Res	Enrolment
106130001	1ST NOVEMBER 1954 JHS	GURUGU	4	KG	4321	36	46
106130002	ADABIYA ISLAMIC PRIMARY/KG	KALPOHIN YAPALA	2	KG	7890	20	15
106130002	ADABIYA ISLAMIC PRIMARY/KG	KALPOHIN YAPALA	3	PRIMARY	502	12	15
106130003	BAGABAGA PRIMARY/KG	SAGNARIGU	2	KG	500	35	33
106130003	BAGABAGA ANNEX PRIMARY/KG	SAGNARIGU	3	PRIMARY	6703	30	29
106130004	BAGABAGA PRIMARY 'A' SCHOOL	EDUCATION RIDGE	3	PRIMARY	4692	28	20
106130005	BAGABAGA PRIMARY 'B' /KG	BAGABAGA	2	KG	5615	23	41
106130005	BAGABAGA DEMONSTRATION 'B' KG	BAGABAGA	3	PRIMARY	1097	34	37
106130006	BARWAH BARRACKS PRIMARY SCHOOL	BARWAH BARRACKS	2	KG	5112	29	28
106130006	BARWAH BARRACKS PRIMARY SCHOOL	BARWAH BARRACKS	3	PRIMARY	4109	37	39
106130007	BISHOP'S R/C J.H.S A	CHOGGU MANAYILI	4	JHS	381	66	63
106130008	CHANGNAYILI A.M.E ZION KG/PRIMARY	CHANGNAYILI	2	KG	2983	45	33
106130008	CHANGNAYILI A.M.E ZION KG/PRIMARY	CHANGNAYILI	3	PRIMARY	510	15	12
106130009	CHOGGU DEMONSTRATION PRIMARY 'B'	CHOGGU HILL-TOP	2	KG	5013	37	43
106130009	CHOGGU DEMONSTRATION PRIMARY 'B'	CHOGGU HILL-TOP	3	PRIMARY	3087	23	29
106130010	CHOGGU NURI-ISLAM KG/PRIMARY	CHOGGU	2	KG	2804	20	15
106130010	CHOGGU NURI-ISLAM KG/PRIMARY	CHOGGU	3	PRIMARY	609	15	16
106130011	CHOGGU YAPALSI M/A J.H.S	CHOGGU YAPALSI	4	JHS	3208	62	81
106130012	CHOGGU-YAPALSI ISLAMIC PRIMARY /KG	CHOGGU YAPALSI	2	KG	3916	20	18
106130012	CHOGGU-YAPALSI ISLAMIC PRIMARY /KG	CHOGGU YAPALSI	3	PRIMARY	7392	18	15

Fig. 3. Sample data from EMIS.

to all manner of learners.

Some educational resources are sharable by learners. These are; classrooms, blackboard, whiteboard teachers, etc. None sharable resources are those that are used by the individual learner in the learning process. These are sitting places, writing places, textbooks, etc. They are provided to be used per student. Some of these resources are re-useable and should not be provided every year. The rate of population growth affects the rate of the population of school-going ages which also affects the rate of enrolment and the rate at which educational resources should be provided.

Problems with physical quantities can best be presented in the language of differential equations(Raissi, Perdikaris & Karniadakis, 2019). Predicting the population of school-going ages and the enrolment in schools necessitates the use of differential equations since it is easier to describe how enrolment changes but not absolute enrolment at a point in time. This makes it more suitable for the population of the school-going ages to be modelled in mathematical equations using differential equations. Integrating the factors or components that affect available enrolment in schools to know the resources needed to cater for learners is vital to accurately planning and providing resources

Using differential equations with an initial value problem, there are three (3) models. Models 1 and 2 are linear models whiles model 3 is an exponential model. Model one looks at the formulation using real-life factors affecting enrolment and resource availability such as a yearly increase in enrolment and the total enrolment at any point in time. Model 2 considers the attrition(reduction) of learners as a factor that affects enrolment. Model 3 tries to make it realistic by considering the proportion of learners that attrite at any point in time since attrition cannot be more than available enrolment.

Let K represent the enrolment per year, M as total enrolment and t is time, M(t) denote the total enrolment at any given time.

Model 1

$\{\frac{dM}{dt} = K, M(t_0) = M_0$ Integrating $M(t) = Kt + c$ where c is the constant of integration $M(t_0) = Kt_0 + c \Rightarrow c = M(t_0)$- $Kt_0 = M_0 - Kt_0$. Substituting the value of c to the equation $m(t) = Kt + c \Rightarrow M(t) = Kt + M_0 - Kt_0 \Rightarrow M(t) = M_0 + K(t - t_0)$. Where there is no initial enrolment,

$$M(t) = M_0 - Kt \tag{1}$$

Model 2

Let A represent the attrition of students per year $\frac{dM}{dt} = K - A; M(t_0) = M_0$ (generalization of module 1) $\Rightarrow M(t) = M_0 + (K - A)(t - t_0)$.

Taking $t_0 = 0$,

$$M(t) = M_0 + (K - A)t. \tag{2}$$

Case 1 if $K > A$ more retention of learners than attrition. Then M(t) increases with time.
Case 2 if $K < A$ more attrition of learners than retention. Then m(t) decreases with time.

Model 3

Attrition of learners is proportional to total enrolment

$$A\alpha M \Rightarrow A = QM \frac{dM}{dt} = K - QM; M(t_0) = M_0$$

Model 3 solution

$\frac{dM}{dt} = K$- QM; $M(t_0) = M_0$. Separating the variables, we get $\frac{dM}{K-QM}$=dt integrating we get $\frac{l\cap|K-QM|}{-Q} = t + c$ where c is the constant of integration. $\Rightarrow$K- $QM = e^{-Qt}e^{-Qc} = Ce^{-Qt}$; $C = e^{-Qc}$ Substituting initial condition K-$QM_0 = Ce^{-Qt_0} \Rightarrow C = (K - QM_0)\, e^{-Qt_0}$. substituting value of C.

$$M(t) = k/Q + (M_0 - K/Q)e^{-Q(t-t_0)} \tag{3}$$

3.5. Steady state of the system

A dynamic system is said to be in a steady state if there is no further change with respect to time. Mathematically, the derivative of physical quantity with respect to time is equal to 0.

$\Rightarrow$ m does not depend on t. Thus $\frac{dM}{dt} = 0$

Computing steady-state solution of model 3

$\frac{dM}{dt}K - QM; M(t_0) = M_0 M(t) = K/Q + (M_0 - K/Q)e^{-Q(t-t_0)}$

From the model, if $\frac{dM}{dt} = 0$.⇒k- QM=0. $\Rightarrow M = \frac{K}{Q}$.

As t →∞.

$$e^{-Q(t-t_0)} \rightarrow 0. M \rightarrow \frac{k}{Q} + \left(M_0 - \frac{K}{Q}\right)0 = \frac{K}{Q} \tag{4}$$

$\Rightarrow M = \frac{K}{Q}$. $M = \frac{K}{Q}$ is the steady-state solution

Total enrolment in school after a long time. M_0 is the initial enrolment and $\frac{K}{Q}$ is the final enrolment at any point in time

Case 1 if $m_0 > \frac{K}{Q}$, *total enrolment decrease with time*
Case 2 if $m_0 < \frac{K}{Q}$, *total enrolment increase with time.*

$$M(t) = k + \left(M_0 - \frac{K}{Q}\right) \cdot e^{-Q(t-t_0)} = \frac{K}{Q}\left(1 - e^{-Qt}\right) + M_0 e^{-Qt} \tag{5}$$

$\frac{K}{Q}(1 - e^{-Qt})$*represents the increase in enrolment and* $m_0 e^{-Qt}$ is for the decrease taking $t_0 = 0$

3.5. The proposed system

The system proposed uses an agile methodology in the development. A structural representation of the technical design of the system as well as a graphical representation for easy understanding is presented in this section. A framework looking at the procedure of getting the data through filtering using data mining tools to the application of an expert system is presented. A sequence diagram with smart notification of actors to facilitate faster response to requests is presented. A use case diagram that looks at the various sections of the system as tasks to be carried out by the actors is also presented with each actor connected to the tasks to be performed. A flowchart diagram of the system is finally presented to take readers through the algorithm of the system to understand both the technical and theoretical issues in the system. These diagrams are presented in Figs. 2-6.

In Fig. 4, electronic data from the schools and education directorates is collated and presented in a dynamic database. This database is frequently updated with current information. As a measure of efficiency, the data in the database is filtered using RapidMiner data mining tools to eliminate errors and also enhance easy and faster classification, analysis, and evaluation. Embedded in the system are the population growth figures which will be used to predict the enrolment of the schools to determine the number of resources needed. This is presented in a neuron of the system in Fig. 5. The analyzed and evaluated data is ten pushed into the expert system component through an interface into the inference engine which deduces the challenges by drawing information from a knowledge-based containing the information regarding the nature and challenges of education. An explanatory facility is available to explain the results of the decisions to the users. Users of the system for decision-making are the schools, education directorates, National School Inspectorates Authorities, and the MoE.

Fig. 6 is a flow of information from one actor(user) to another. Smart notification is embedded in the system to alert users to respond to

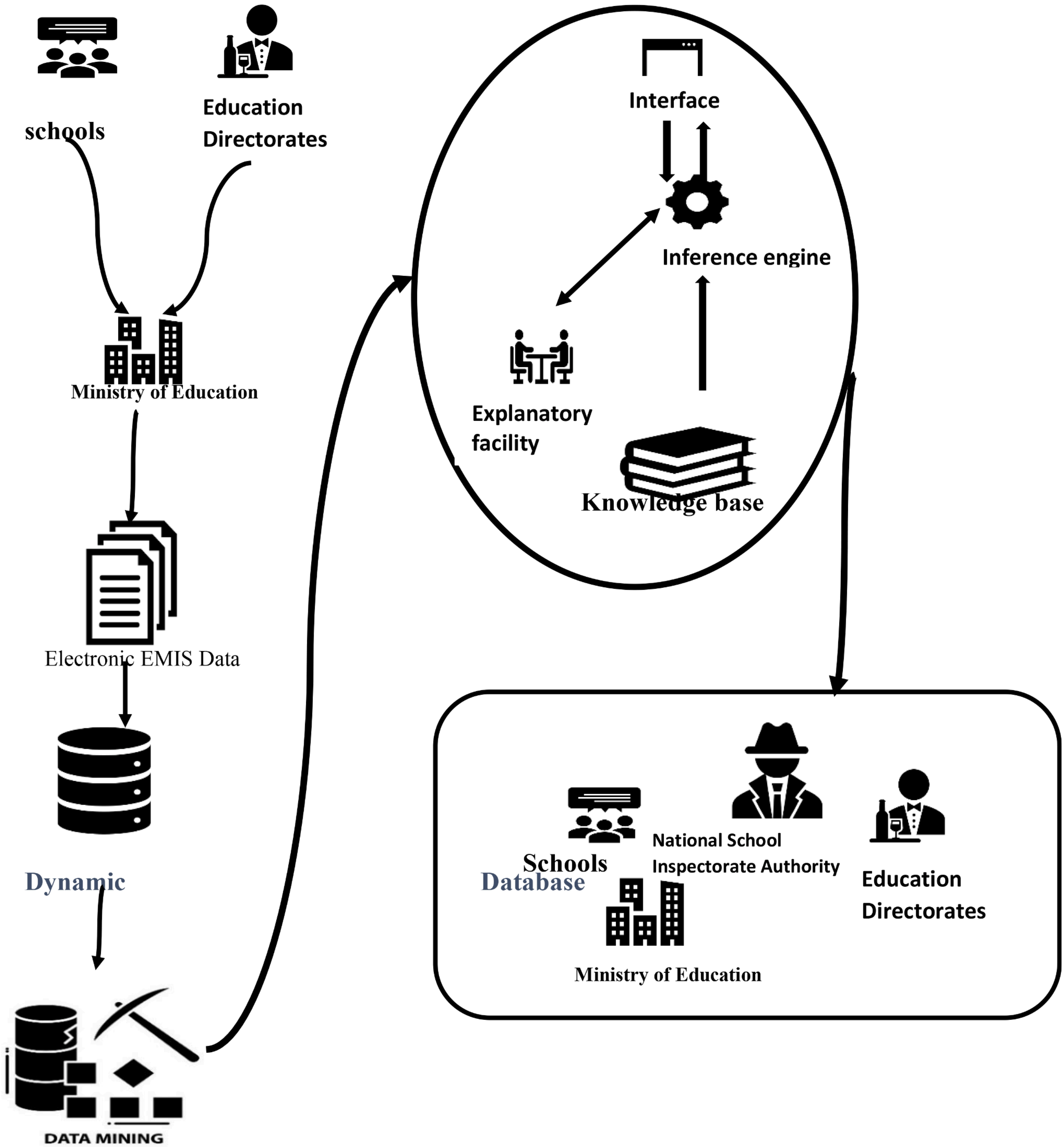

Fig. 4. Framework of the proposed system.

transactions quickly. In the system, Ministry will send information to schools and the education directorates regarding the challenges identified with the data available. Schools will authenticate the request which should be seen by the district directorates for confirmation of the accuracy of the challenges identified regarding the needs of the schools. As a measure of checks and balances, the NaSIA which is in charge of monitoring the availability of resources in schools also sent the request to confirm the resources and the challenges of the schools to the ministry. This cycle is repeated till all reconcile and agree to the challenges. This may take a single day to achieve if all parties are working effectively.

In Fig. 7, the four users of the system are the school, education directorates, education ministry, and the NaSIA. Both schools and education directorates can send requests for resources and also confirm notification of the availability of resources and the challenges in schools. The education ministry authenticates requests sent by schools and education directorates. The ministry also confirms the availability of resources in the schools and education directorates using the EMIS data. Approval of the accuracy and reliability of the information of the schools and education directorates is also made by the ministry. The NaSIA approves the provision of resources to the school after checking the enrolment and the available resources in the school.

From Fig. 8, the various institutions in charge of the provision and management of educational information provide the data to the EMIS.

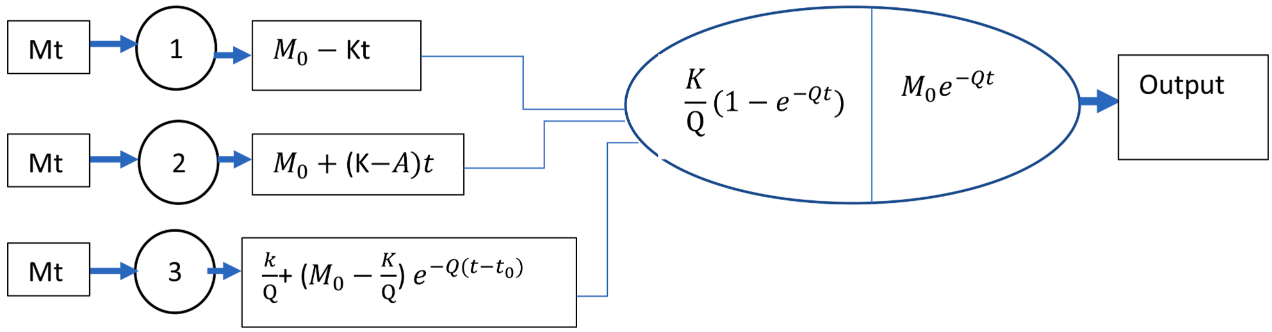

Fig. 5. Structure of a Neuron in the System.

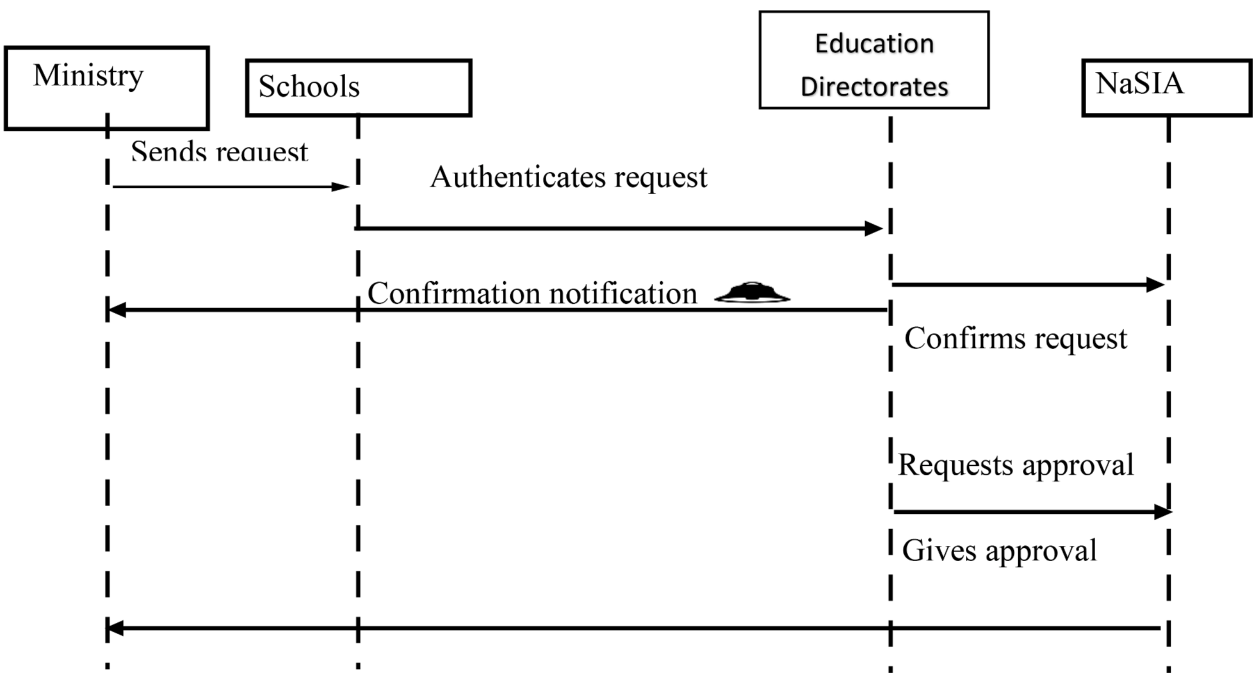

Fig. 6. Sequence Diagram with Smart Notification.

The data is then processed through the data mining software (Rapid Miner). Filtering the data to eliminate errors, clustering and classifying the data based on the challenges and locality types are the tools and techniques to be used. The processed data is then uploaded to the ES to determine the challenges and the proposed solutions for the various schools. The various stakeholders of education will then access this information through the ES and apply the necessary interventions. In Fig. 2, a sequence diagram with the smart notification is used. The MoE will send a request in the form of reports of the schools and the various Education Directorates with a smart notification. NaSIA will confirm the reports and the recipients authenticate the reports sent and confirm the notification as an acknowledgement. A request for approval is then sent to NaSIA and they approve the request for that challenge to be registered and solved. In Fig. 7, a use-case diagram of the system is presented. The various stakeholders as actors of the system interact with the various classes in the system as indicated. Last but not least is Fig. 8 which represents the flowchart of the proposed system indicating the user actions and the processes in the system.

4. System and model evaluation

To the best of our ability, there is no known expert system for managing basic educational resources. There is also no known process for evaluating an expert system for managing educational resources. The general system evaluation process is used to evaluate the system concentrating on three (3) areas in measuring the efficiency. These areas are; speed, accuracy, and ease to use. The model evaluation is also done using real-life data from the ministry of education in Ghana to check the accuracy.

4.1. System evaluation

A comparison of the expert system to that of the traditional system of managing resources in basic schools is necessary to know the efficiency of the system. It is also vital to test the system for sustainability and the test of time. The requirements for the development of the system are revisited to see if the scope has been covered. This is compared to the real-life work of the management of basic educational resources after integrating the system to work. With a target of completing decision-making in one day, the speed, cost, and easy collaboration for consistency of the various stakeholders involved are compared. Table 2 shows the results.

Table 2 compares the results of the HE to the ES in speed and consistency in decision-making. Without the ES, bureaucracy and inconsistency are the major challenges in decision-making. With a target of making a decision in one day and getting consistent results using 10

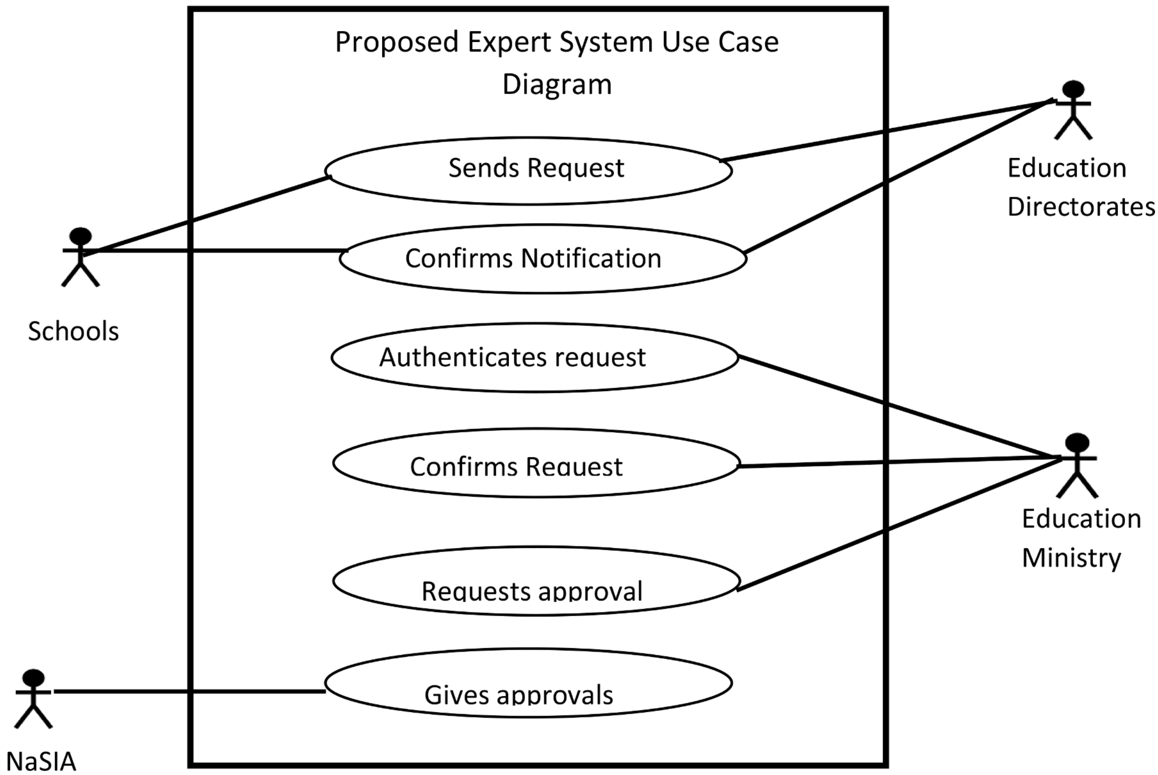

Fig. 7. Use Case Diagram of the Expert System.

decisions as a test, the expert system can achieve the completion of a decision within one day due to the smart notification of the stakeholders. This is however not possible using the human decision-making process. The long chain of consultations and approval of documents introduces latency to the completion of a decision. The fastest decision can be completed in 14 days which is equivalent to 2 weeks. This gives the human expert a 0.071 ratio of a decision to days and 7.1% speed whiles the expert system gets a ratio of 1 which is a representation of 100%. The cost involved in travelling and printing documents is also high compared to the paperless expert system without transportation costs. In comparing the consistency, out of 10 decisions made, the human expert decision can achieve a maximum of 5 decisions for consistency but the expert system will produce the same results given the same inputs. This gives the human expert decision a maximum of 50% consistency and the expert system can achieve 100% consistency.

4.2. Model evaluation

As the steady state of the model has been proven to show the stability of the model with time, it is vital to consider the already existing data of basic educational resources to see how best the model can fit into a real-life situation. Model 3 is $m(t) = k + (m_0 - \frac{k}{Q})\ e^{-Q(t-t_0)} = \frac{k}{Q}(1 - e^{-Qt}) + m_0 e^{-Qt}$ as the $\frac{k}{Q}(1 - e^{-Qt})$ represents a growth and $m_0 e^{-Qt}$ represents a decay. Both are represented to know the real-life situation of the model. The decay is a representation of a reduction in enrolment in the schools. This possibility is an unlikely event as the population of school-going ages keeps increasing and the demand for more resources to cater for the growing population is necessary. All children of school-going ages are supposed to go to school. The growth on the other hand represents an increase in the enrolment of schools. This is the expectation and the likely event as the enrolments of schools keep increasing due to an increase in the population of school-going ages and the need to cater for all manner of learners in schools. As the focus of this paper is on the availability of resources to improve teaching and learning to achieve the desired quality education, the $\frac{k}{Q}(1 - e^{-Qt})$ is given much attention as it is the part that can help in planning resources for the growing population. However, the general model is considered to enable knowing easy progress with time and the ability to cater for both increase and reduction in enrolment. A two-decade trend of data is used in evaluating the model to know the true reflection. Table 3 is the results.

In Table 3, real data from kindergarten education in Ghana from the year 2001 to 2019 is used to evaluate the model and a graphical representation of the results is presented in Fig. 9. It is clear from the results that the model is exponential and can work in a long run. With these results, careful planning of resources to cater for learners is relatively easier. As enrolment is progressive, both shareable and non-shareable resources are supposed to be provided to enhance quality education in schools.

5. Findings and discussions

As the population of school-going ages increases and the enrolments of schools keep increasing, adequate planning and provision of resources to basic schools to enhance effective management of teaching and learning in schools is a necessity. To cater for the growing population and maximize the use of resources, proper mining of educational data is necessary before any meaningful decision can be made. To assist non-experts in decision-making for the effective utilization of resources, the expert system is a good proposal. This system with an enhanced rule-based inference engine combines neural networks to assist in making easier the identification of the challenges and solutions to basic education by first classifying schools into urban and rural with subsequent clustering of the classes into endowed and deprived schools using the availability of resources as a reference.

From the proved by contradiction, $\neg\forall e \exists r, P(e) \equiv (\exists e \notin r)(\neg p(e))$, not all enrolled learners in schools have access to educational resources for effective teaching and learning. This affects the quality of education in a country. The quest to know the available enrolment in educational institutions and plan towards the provision of resources for all manner of

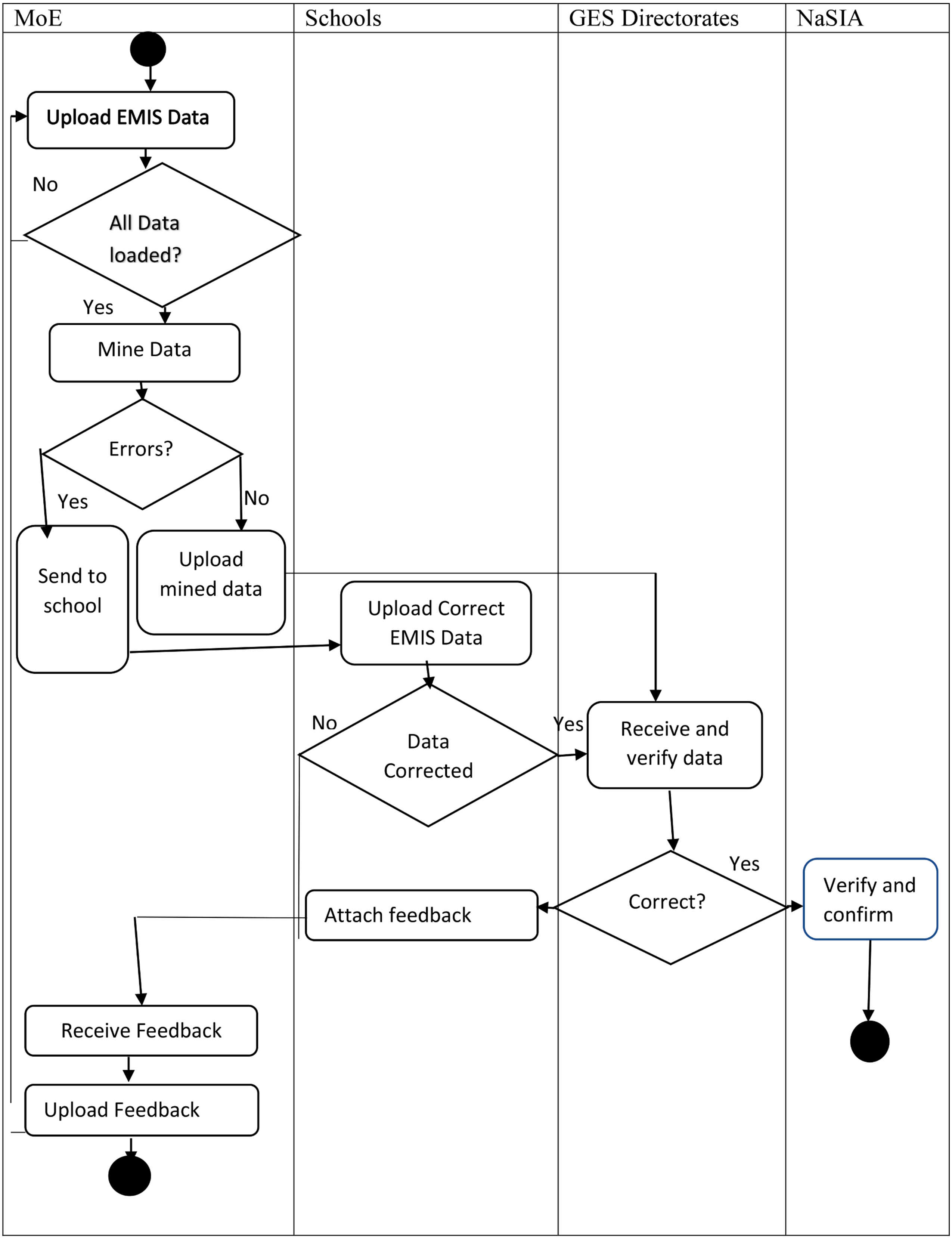

Fig. 8. Flowchart for the Proposed System.

Table 2
Comparing Human Expert Decisions and Expert System Decisions.

Activity	Human Decision	Expert System	Variance
The average number of days a decision can be completed	14	1	13
The ratio of target days to actual days	0.071	1	0.929
Percentage speed	7.1	100	92.9
Consistency of results for every 10 decisions made	5	10	5
Percentage consistency	50	100	50

Table 3
Results of Real-Life Data for the Model.

T	K	M	A	Q	$\frac{K}{Q}+(M_0-\frac{K}{Q})\,e^{-Q(t-t_0)}$
1	235,687	457,597	179,986	0.3933286	503,649.0205
2	249,876	516,734	199,876	0.3868064	614,022.5251
3	256,745	519,957	201,580	0.3876859	638,720.4466
4	266,802	547,950	205,449	0.3749411	690,730.2768
5	469,210	807,369	380,815	0.471674	976,086.4779
6	512,921	896,522	383,601	0.4278768	1,177,833.234
7	593,203	1016,606	473,403	0.4656701	1,262,338.465
8	626,277	1078,973	499,898	0.4633091	1,343,667.625
9	678,456	1180,760	481,192	0.4075274	1,653,471.078
10	683,816	1199,967	496,944	0.4141314	1,644,222.828
11	695,013	1226,132	495,013	0.4037192	1,716,046.054
12	710,271	1241,093	515,861	0.4156506	1,705,678.105
13	732,686	1285,497	508,407	0.3954945	1,849,580.201
14	748,494	1287,354	536,985	0.417123	1,792,989.289
15	765,655	1289,541	521,699	0.4045618	1,891,332.002
16	766,969	1290,144	522,572	0.4050494	1,892,710.257
17	790,146	1297,635	499,998	0.3853148	2,049,812.585
18	768,587	1305,678	509,048	0.3898725	1,970,881.273
19	786,543	1329,876	512,678	0.3855081	2,039,892.333
20	897,654	1354,987	530,234	0.3913204	2,293,641.223

learners resulted in the module 1 $M(t) = M_0 - Kt$ where enrolment of learners to educational institutions is considered with time as the accumulation of the learners continues. This model is far from reality as learners do not stay in educational institutions forever. Enrolled learners leave the educational institutions after completion or attrition. This results in module 2 $M(t) = M_0 + (K-A)t$. The attrition of learners is considered in the form of completion or accidental dropout, death, transfers etc. This is close to reality but will only prove its efficiency for a shorter period since it is a linear model. It may not also fit real data in prediction. In module 3, the reality of the enrolment and movement of learners is clearly shown. Enrolled learners leave educational institutions proportionally to how they are enrolled. This brings the exponential module $\frac{K}{Q} + \left(M_0 - \frac{K}{Q}\right)e^{-Q(t-t_0)}$. In the steady state solution, the module proves that there is no further change with respect to time. $\frac{K}{Q}(1-e^{-Qt}) + M_0e^{-Qt}$ where $\frac{K}{Q}(1-e^{-Qt})$ shows the increase in enrolments and M_0e^{-Qt} shows the attrition of learners. As the main objective of the study is to cater for the growing population, the $\frac{K}{Q}(1-e^{-Qt})$ is considered to cater for the availability of resources to them.

As indicated in Table 1, previous research works such as (Akyeampong & Hunt, 2016), (Ametepee & Anastasiou, 2015, (Asare & Osei-Kuffour, 2021)) and (Mereku, 2019) attempted to address the challenges of education without accurate tools to identify the challenges and predict solutions. Carefully addressing the challenges of basic education requires a flexible multi-disciplinary approach and techniques as indicated in (Inusah et al., 2021). The methodology applied in this research work will help in tracing the errors in data and also assist in accurate planning and implementation. The use of agile neural methodology can easily help in tracing the challenges and the solutions. In Figs. 1 and 2, the system will achieve flexibility in contributions from both the domain expert and the knowledge engineer with the careful presentation of the issues. The description of datasets presented in Fig. 3 helps in knowing the nature of the data and the system to appropriately model it. As the data is already existing, SQL statements are used to fetch the data to enhance interoperability for the elimination of errors. In Fig. 4, the framework of the proposed system presents the core issues to be addressed in the system. The neuron of the system in Fig. 5 presents the mathematical models to depict the targeted population and the results in the provision of resources. The use of smart notification in the sequence diagram in Fig. 6 enhances speed to reduce the latency in the

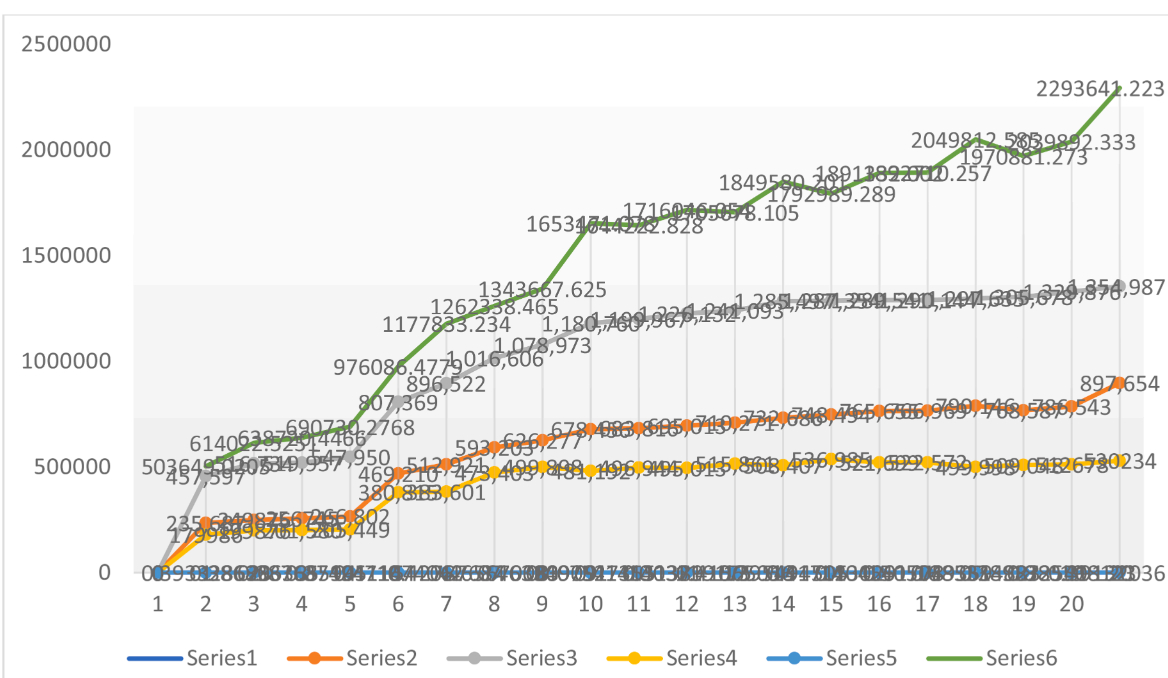

Fig. 9. Line Graph Representation of Model Results.

decision-making. The use case diagram in Fig. 7 presents the major actors in managing basic schools which are; the schools, the ministry of education, the education service, and the national school inspectorate authority. The interoperability of their activities is represented in a sequence diagram. These interactions are done with smart notifications to prompt every user of the system to respond to a request faster. Latency in decision-making is eliminated with this approach. The use case diagram of the system is presented to know the various activities carried out by the actors in the system. This spell out the role of each actor in the system. Fig 8 clearly shows a flowchart depicting the inputs, processes, decisions and output of the system. Maximum efficiency can be seen in this system as iterative processes are reduced to enhance speed and accuracy. This simplified but technical representation of the system makes it more robust to fit into the system of basic educational management. Operationalization of the system in the real management of schools is enhanced with ease.

The merits of this proposed system far outweigh that of the previous studies. The effective visual analysis of the system presents a realistic picture of the human real thinking of the problem. This will enhance the analysis of information and synthesis into different forms.

Organization of data and filtering of unwanted elements in the data before analysis enhances the accurate identification of problems. As this system helps in arranging unorganized data, speed and accuracy in results will be achieved in using this system to address problems. This spares the human expert the time in re-organizing data before analysis.

The system has an adaptive structure which makes it fit for all manner of data. It can serve different purposes in nature with similar challenges in related fields of study. A carefully chosen user interface enhances easy interaction by an average user of a system. This system has a well-designed feature to enable users to interact at their own pace with little or no support.

Compared to the available research works in Table 1 which uses reports, tables and graphs, this work gives an in-depth analysis and clearer picture of the problem from the point of data gathering to the final point of identifying the challenges and the solutions to educational problems using predictive models.

Evaluating both the system and the models to know the level of efficiency is a necessity. No known expert system for managing basic education is available in the literature and no known evaluation for this system is available to the authors. As indicated in Table 1, general system evaluation parameters are used. A comparative evaluation to that of the human expert reveals a very high efficiency for the proposed system.

6. Conclusion

This proposed expert system considers the challenges of basic education in the aspect of resources available for effective teaching and learning in schools to achieve higher quality education in a country. Faster identification of the needs of schools through a rule-based neural expert system that accurately finds the challenges of a school and matches them to the appropriate solution. This is after the data of the schools gathered by the ministry of education through the education service has been processed through data mining tools to enhance more accuracy of predictions. Modeling of the population growth and the enrolment in schools is properly represented to know the expected resources needed at any point in time. A smart notification system is embedded in this system to prompt every user for an action required to enhance faster decision-making for the provision of resources to schools. Real-life data on basic education in Ghana has been used to evaluate the model to know the level of accuracy. As the expert system for managing basic education proves a higher efficiency than human decision-making, the adoption of the system can help address the challenges of education in a country. Since basic education is the core of education in a country, proper planning and provision of resources for effective teaching and learning will help in achieving success in education. The collaborative effort of all stakeholders in education is necessary for achieving this. High budgetary allocations to education and subsequent high expenditure in developing countries will be minimized if this proposed system is used. Eliminations of errors in data entry through the application of data mining techniques help in getting accurate data for accurate predictions in decision making. This enhances efficiency in the management of basic education. The improper allocation of educational resources which leads to some schools having excess while others are lacking will be eliminated. The barriers to education for all categories of schools will be eliminated if this system is adopted. Donor funding or support for education in developing countries can be channelled to other areas for better development of the nation. Reflection on the provision of resources to schools will be seen and the issues of social media or mass media reportage on challenges of education will minimize if not eliminated.

7. Limitations

As the system depends on data collected from schools by the Ministry of Education, the accuracy of results strongly depends on the accuracy of the data provided. Though the system can identify and correct some errors through the data mining tools, not all errors can be detected and corrected. Inadequate information and inaccurate information can affect the results of the system.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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