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Chapter 2: Leveraging connected intelligence to enable smarter decision-making across educational institutions and renewable energy infrastructures

2.1 Introduction

The quality of decision-making in any field is critically dependent on the level and quality of the available expertise concerning the problem domain. In domains such as education and renewable energy, the understanding of the factors and the impact of the naturally occurring interdependencies and interactions among them is limited. For example, research has revealed the existence of significant interdependencies among solar panels within a solar power installation, and among student drivers who learn to drive in the same car. Knowing the sign and strength of these solar panel interdependencies has important implications, for example, to the selection of the solar domain for stock market investors and rewarding educators who teach drivers safer driving behavior.

The goal of this project is to leverage connected intelligence for enhanced decision-making. The key aspects of the approach are the following: the development of models that take into account the interdependencies that naturally occur in the domains of higher education and renewable energy, the estimation of these models, and the use of the estimated models to address policy-relevant questions in these domains. The team on this project is multidisciplinary and includes experts from the fields of computer science, economics, and transportation. The outcome will be improved expertise that can be used to enhance decision-making in the domains.

2.1.1. Overview and Objectives of the Study

The concept of the Internet of Things (IoT) refers to the increasing number of devices that can access the Internet. Such devices typically carry out sensing and actuating technologies. Data generated by these smart and connected devices provide a detailed understanding of real-world phenomena that can be used to enable amendments, refinements, and optimizations. Furthermore, the standardization of connectivity technologies paves the way to a generalized and uniform approach to the design of any service or portfolio of services. The synergy of big data, machine learning, and IoT has the potential to revolutionize most economic sectors, especially energy and transport. The comprehensive objective of this study is to investigate the use of connected intelligence as an enabling technology for leapfrog behavior in the sectors that are instrumental for the transition to a clean economy, namely renewable energy sources and public and private education. More specifically, this study is concerned with several proprietary services provided by two different companies.

The research and innovation activities are primarily focused on networking issues for smart devices and sensors in the context of smart grids, whereas the other company specializes in advanced services for public and private education. We aim to demonstrate that data science methodologies and IoT both play a crucial enabling role and provide more advanced, yet simplified, services in the domains of education and renewable energy, thereby contributing to faster and steadier progress in the two respective domains. Energy and education have been chosen as representative examples, but the approach is general and is also effective in addressing challenges and opportunities in many other domains such as transportation, sparsely inhabited areas, and crop quality. To the best of our knowledge, no study has investigated and pointed out the value added of connected intelligence in these two specific domains and tackled challenges in real-world settings.

2.2. Understanding Connected Intelligence

Connected intelligence refers to a collection of technological capabilities for the connectivity of numerous devices, data collection, storage, scanning, matching, threading, processing, and analyzing that data. These capabilities are achieved using the performance of capability models for big data, cloud, scalability, and artificial intelligence (Annapareddy, 2022; Chakilam, 2022; Challa, 2023). The advances in sensing, communication, and computing have provided us with an unprecedented ability to connect the physical world in ways that are valuable for several applications. The Internet of Things and big data can be leveraged to connect things, collect and store data, process data, and provide valuable insights, interactions, decision-making, and other capabilities to inform and solve problems with immense social, business, and regulatory value. A few essential components and capabilities are needed as a foundation to take advantage of those strengths collectively. Firstly, a robust, reliable, and scalable network of wireless technologies connecting a wide variety of sensors and other interconnected devices is needed to enable connectivity. Secondly, the capability to collect and store a massive amount of data, and process it quickly through diverse scanning, matching, threading, and machine-learning techniques is also vital.

Machine learning techniques and AI models, especially multi-agent models and those that incorporate participatory processes, are particularly useful for offering superior capabilities over traditional means to make sense of the vast sources of streaming data (Chava & Rani, 2023; Kannan, 2022; Komaragiri, 2022). These capabilities are applied, among other things, to make informed, data-driven decisions, informed participation in various activities and use cases, creating informed interactions, safe, secure, and private designs, and informed regulatory, compliance, and other guardrails. Furthermore, connected intelligence also incorporates non-participatory means that are essential in some interactions to develop and deliver the capabilities with sufficient accuracy and adequate human oversight. Such capabilities, through live data of matched entities in specific segments, are essential to developing superior services and other offerings in information and participation. This must be connected with essential regulatory and oversight guardrails and those applying data privacy and protection principles in a connected world.

Fig 2 . 1 : Understanding Connected Intelligence

2.2.1. Definition and Scope

In higher education and the world of renewable energy, as well as in many other areas of the business, science, and engineering sectors, tremendous volumes and varieties of data are generated on an online basis from human and machine sensors. Sensors represent a fundamental component for integrating our physical world with computer-based systems. Today, fuel cells are the primary fractionation systems under consideration. These "connected" intelligent systems offer opportunities for better understanding and decision-making in these domains. The concept of connected intelligence (CI) centers on the control and management of a set of collected data to search for patterns and behaviors for which the system being monitored is unstable, unreliable, unsecured, or misbehaving. Being alerted to these conditions can trigger decision-making that is both timely and corrective, avoiding potentially serious economic, health and safety, or other social consequences.

Here, we introduce M2M, CI, and the collaborative, which starts by using CI as a teaching and learning focus to collectively leverage the transformative impact that new online data are beginning to have on the way people in different educational stages of universities and colleges are making educational infrastructure investment decisions and are engaged in a variety of energy conversion and environmental management and risk analyses. The objective is to create enhanced infrastructure for education in support of next-generation bioenergy systems, financial models of educational infrastructure investment to include a consideration of the potential value added of CI monitoring as an input parameter to project pre-assessment, designs for fuel cell systems with an effective product cycle lasting, secure and monitor current and future operational performance of transportation and fixed-site fuel cell systems, and foster improved understanding and decision-making.

2.2.2. Technological Foundations

Several major industries are rapidly increasing in the interconnections of the digital world. Evolving educational and renewable energy needs and technologies can benefit from the advancements of this interconnected world, such as big data management, artificial intelligence, ubiquitous high-speed internet, the Internet of Things, and next-generation ICT infrastructure. Modern AI tools provide corporations and organizations with predictive analytics, optimizing models, and machine learning algorithms to fast-track decision-making, usually combined as "data intelligence" for business intelligence and corporate innovation. Educational institutions and renewable energy operators can trust, respect, sustain, and propagate both AI and machine learning skills. Humans have a unique set of capabilities and blind spots; for maximum performance and protection, AI systems should be harmonized and combined with humans.

The term "connected intelligence" refers to these methods and facilities as a continuum of interactive conversations around collection, interpretation, and the use of information that supports trust and decision-making, understanding, and doing the right thing. Prototyping good equity, good information capital and general innovation is crucial for the enhanced results of effective connections. The CI schema allows an educational institution, for instance, to establish management policies and legal processes for standard institutional AI and data science defenses using upskills and new information. Reinforcing decision rights is a lower risk and a longer-term journey that helps to accelerate intelligent advanced sustainable progress. If users confidently rely on the learning outcomes and feedback from computer-based learning analytics and data-driven workloads in education and other available industries, then they are more likely to be eager to use AI.

2.2.3. Historical Context

All the efforts of education for the environment and renewable technology development started to matter only in the 1970s and 1980s, particularly with the first oil crisis in 1973 and the return of oil prices in 1979, which led many countries in the world, including Brazil, to seek solutions in the transition to cleaner, inexhaustible, and endogenous sources. In the area of education, it was a time of reaction against traditional teaching methods, based on the accumulation of knowledge and spontaneous memorization, with the introduction of understanding requirements of the essential concepts of science and technology for the use of this knowledge in decision-making, moral values, responsible behavior, and real-life situations, both domestic and work-related. Policies and programs at the national level for renewable energy and energy conservation began to appear in developed countries, especially in the United States, whose unpreparedness for the availability of fuel to generate electricity, considering the expansion of electricity consumption, led Congress to abandon periodic considerations of electric projects, with the promulgation of the National Research, Development, and Demonstration Program. Small hydro, solar, wind, and geothermal plants were developed, tested, and put into operation, and at the end of the 1970s, solar systems were being seen as a long-term solution.

2.3. The Role of Connected Intelligence in Education

Connected intelligence (CI) begins with the union of social, enterprise, and machine intelligence to reveal interconnected structures between social entities (Malempati, 2022; Nuka, 2023; Sriram, 2022). It manifests as an object space on a network in which each point comprises a social or enterprise object such as a student, course, grade point, or business, and their localized social interactions. CI provides a novel spatiotemporal framework for extracting important and concentrated knowledge leading to informed decision-making. This is particularly relevant within education where fundamental reforms are required to advance human knowledge in an increasingly competitive globalized world. Problem area topics of CI are characterized independently of dataset attributes leading to a model-free approach. CI relies on architectural, location, time, or event fingerprints to provide decision-makers with a contextualized view of visualized aggregated data subsets related to academic, health, educational, or business domains that may preclude exhaustive domain knowledge to specialize. Educational exploration, target mapping, and a matrix guide are introduced to offer educational and management insights such as predictive learning groups where pronounced performance improvements can be realized in future grades.

CI possesses the interconnectedness of knowledge allowing it to structurally move with its associated data providing new perspectives to reveal latent attributes to inform education policy, planning, and instructional strategies. Knowledge condensed through CI is guided by characteristic domain signatures, such as residential, dining, class, teaching, exams, and performance-based groups, that facilitate a model-free approach capable of extracting knowledge revealing representative characteristics of all entities. The framework and methods are first introduced and then their merit is demonstrated via representative academic applications. Unique observations are undistorted by formulas or domain-specific matrices of descriptive statistics, correlation, or determination that may inadvertently avoid potential underlying knowledge. By leveraging knowledge in this manner, academics and students will optimize teaching, learning, and policy dissemination to exhibit increased performance since predictive continuous and classification models are inherently embedded.

2.3.1. Data-Driven Decision Making

Traditionally, much of the world's thinking and learning has been driven by belief systems and empirical findings. We also rely on vicarious representations of others' experiences told in the form of stories, personal experience narratives, and other forms of folk knowledge. Data has become relevant through purposeful research. Research findings are often challenged, leading to more research and results, and eventually leading to some level of expert consensus—typically whatever comes into the scope of a professional society. Research-based interventions sometimes secure enough evidence to be considered original but may not contain evidence of what works in settings that more closely resemble everyday learning practices. Our knowledge is further enriched if studies use models that incorporate latent factors, moderators, and mediators, confirm overall understanding and implementation best practices, use validated measures, or investigate the usual activities when learning by simply measuring or evaluating variables. Educational administration encapsulates all these functionalities, yet it is clear that more timely access to data, analyses, computer sciences, strong, large, and complex data, governance, and ethical case study data, as well as systems to train and recognize data-driven education, for full generalization, are required. By distinguishing data-driven learning processes from outcomes, pupil-driven education is implemented cyclically.

To successfully apply data-driven decision-making to educational institutions, it is essential to create a supportive policy environment since there are varied stakeholders involved (Nuka, 2023; Sriram, 2022; Suura, 2025). Writing, innovating, and monitoring different policies provide the supporting framework that facilitates the necessary demographic data. In the absence of a supportive policy context, educational institutions increasingly rely on evidence that can also be proven using data. The concept of evidence-informed practice requires familiarity with noted issues over generations. As a community interested in the impact of connectedness on education policy and decision-making, it is well aware of the massive challenges that come with facilitating end-to-end, verifiable decision-making processes in education. Yet it is important to suggest that statistical evidence is still critical in tackling education problems and supports data-driven policy-making. Data-driven decision-making is the official policy of the Department of Education's National Center for Education Statistics.

2.3.2. Personalized Learning Environments

In the idea of a personalized learning environment, an intelligent tutoring system with personal familiarity information. This system adjusts not only the instructional process but also its content without any explicit modeling of the learner. Another example of the idea is customization. It integrates the learner model within the system architecture and uses case-based reasoning to skip the traditional design of the instructional plan and content at processing time. A more complex approach combining case-based reasoning with explanation-based learning is reported. This system suits the instructional plan and content by relying on a learning controller, which is based on an explanation-based learning process modeling system. Introducing a decision-theory-based model deals with the broader problem of creating an adaptive computer-based system. It moves learning and adaptation one step higher by incorporating stages for improving the learning capabilities of the system itself.

It is not the adaptive visualization of the tutoring system. User modeling and human-computer interaction techniques are described for the task of real-time inference about user intentions and the conjunction of these user intentions with the corresponding user models. Our environment is part of an intelligent instructional system that constructs context-dependent student profiles for symptoms to give useful advice about drug prescriptions. Our approaches imply that the personalization of the environment occurs on short time scales. Over longer time scales, we expect that learning can occur, both in our environment and by the inference engines in the intelligent tutoring system. For example, the tutoring system might learn new ways to present therapeutic knowledge to the students or partial treatment knowledge from the user; and to a certain extent, the environment might learn to understand erroneous or incomplete information given by others or might revise what it has previously inferred.

2.3.3. Collaboration and Communication Tools

Feature 10: Collaboration and Communication Tools If connected educators want to increase their impact, they need more efficient ways to collaborate and communicate. Stated simply, there still is not a single tool or channel to engage education professionals in effective and inclusive discussions. As one teacher reported, “I have no time during the day to have face-to-face conversations, which sucks because many thoughts that I have could be very productive to my practice. I would join in on this, but honestly, I don’t have the time to participate because there is no time to have a real discussion.” The participants recognized that communication is a two-way street. As one individual stated, “Not only do I engage my thoughts and perspectives, but I also learn from others and improve my understanding and perspectives.” These are valid points, and it is not surprising that teachers are frustrated by the status quo and genuinely want to engage more effectively.

The group believes that successful conversation and cooperation have the potential to lead to real and effective collaboration in supportive environments. The participants in our ongoing discussions believe that there are untold advantages for all involved, as this will help everyone work toward common goals. Therefore, it is generally advantageous to have more collaboration and effective communication tools, and we will provide more specific examples of tools that exist. There are too many challenges for any particular system to remain the single location for conversation, but the discourse about collaborative and cooperative systems is essential to move beyond just the initial implementation or criticism to the point where the tool truly helps fulfill its original intent and delivers. Our working group, therefore, remains focused on the quality of design over features or implementation.

2.4. Connected Intelligence in Renewable Energy

The increasing interconnectedness of renewable energy systems with ICT presents unprecedented potential for enhancing decision-making via connected intelligence techniques. Three distinct components in renewable energy systems can form the basis for informatics studies; these are: energy generation with various production components, transmission, and distribution, which are important for the energy flow from producers to consumers, and lastly, the consumer is the final beneficiary of the whole operation. The development of appropriate theoretical models and efficient operational methodologies to embed the increasing amount of information becoming available from these perspectives can lead to a variety of beneficial tasks, including, but not limited to, ensuring the enhanced operation of renewable energy systems.

Renewable energy data from the smart grid, with the help of advanced analytics techniques, could offer an in-depth understanding of the manufacturing process in a particular enterprise. By comprehensively collecting energy-related information, such as real-time monitoring of the energy parameters during operation and the management of renewable energy production facilities, big data management technologies can further enhance manufacturers' opportunities in the renewable energy sector. The massive data set will provide valuable information to detect and analyze problems related to renewable energy facilities, leading to predictive maintenance calculations, optimization of project lifetime, reduction in investment risk, and extended plant reliability. Additionally, by using historical big data analytics, manufacturers may calculate which system components, including modules, strings, and inverters, are likely to pose problems in the future, enabling them to make timely and accurate choices. Providing manufacturers with such information will lead to cost reductions for customers during the life of the project, as it may prevent long-term repairs and operations. Finally, by greatly improving the understanding of renewable energy production, smart grid big data derived from the renewable energy sector can be used to create completely new business opportunities.

2.4.1. Smart Grids and Energy Management

Smart grids are intelligent electricity networks that ensure the efficient integration of renewable energy with connected intelligence. These grids use smart sensing for integrating various components and sensors, enabling bidirectional communications to integrate energy management solutions, bidirectional communication, and create flexible power networks. With smart grids, real-time pricing takes effect to provide near or real-time market conditions for meeting changing demands with suitable responses and necessary incentives. This helps in creating a future-proof infrastructure and provides accessibility to renewable energy from various sources.

One key area of computer science includes the design and analysis of algorithms for controlling the devices that make up a smart grid. For example, when a new electrical technology is developed, such as solar panels, additional controls, and algorithms are needed to integrate these technologies effectively into the electrical grid. Often, these algorithms must balance multiple, often conflicting, objectives, such as minimizing the costs to consumers, minimizing the electricity consumption of the grid, or ensuring fair access to the new technology. In contrast with many other fields of computer science, a key focus of smart grid research is to enable a real and practical impact. Although there can be a significant impact from designing new algorithms and proving performance guarantees, if these algorithms do not work effectively, they will not be used by grid operators. Thus, the impact is an equally important consideration in smart grid research.

2.4.2. Predictive Analytics for Energy Consumption

Libraries consume a significant amount of resources in the form of energy for their daily operations. Predictive analytics for energy savings are mostly used for buildings and commercial spaces where features of the building, such as shading characteristics, artificial illumination usage, occupancy, location, structure of the building, HVAC, and its control, are utilized. To the best of our knowledge, these techniques have not been leveraged for energy savings in libraries. Hence, this study focuses on reducing the energy usage of libraries using features together named storage with a combination of temperature and humidity data. By using a weekly dataset, runs were carried out to study the daily patterns of data, annual daily replications of building data, and their long-term patterns through the processing of unsupervised learning, lossless feature reduction, and clustering. Building-related data are collected through an error-tolerant signature-based energy model approach. Results show that when these signature-to-energy reduction techniques are used, the energy consumption of the library could be decreased by 26% over 24 hours of operations.

Library Operational Maturity Levels (LOML) showed a significant reduction in library energy usage with the technology used in the multi-solution approach. Peltier cooling technologies showed significant benefits associated with a combined effect, high energy efficiency in energy harvesting, installation cost, and dual solution approach. The materials that we are using need to be processed and prepared for the mass production of the Peltier on-chip energy. Overall, multi-solution miniaturized technologies are expected for energy-harvesting miniaturized solutions in the future, leading to a decrease in library energy consumption. Given the vacancies and available funding, we believe that the multi-solution approach is a viable alternative to more costly on-site renewable energy storage products.

2.4.3. Integration of Renewable Sources

In recent years, the share of renewable sources like wind has been growing increasingly worldwide. They have become an important part of the energy mix in several countries. Thus, in recent years, when considering energy planning, the integration of renewable energy sources, which involve variable and not easily controlled generation options, has been increasing in importance. The uncertainty associated with the integration of these sources arises because of the following non-systematic factors: the seasonal and diurnal aspects that support the portfolio effect, as well as the eventual contrast between excess production and periods of very low production during which these sources are not available. They can involve a complex trade-off to ensure system stability.

Fig 2 . 2 : Renewable Energy Infrastructures

The variation in wind flow and, consequently, the level of wind production have different time scales. The most significant ones stem from seasonal changes, the annual variation of wind load factors, and wind speeds that can be exploited, regardless of energy storage constraints. These variations represent an extreme problem, and their predictable removal is almost impossible. Traditionally, it is possible to adopt a model, together with an associated degree of confidence, which is based on the seasonal analysis of the historical record of the annual energy of the wind turbine generator. Such an approach allows the distribution of a set of annual values, within an acceptable level of confidence, which can be exploited for energy purposes without significant use of additional storage. The expected trend of technical development in wind technology may imply changes in the load factor of new devices. Therefore, these changes should contribute to this issue by developing higher load factors that could ensure the integration of increasingly large shares of wind generation in the energy mix.

2.5. Case Studies in Educational Institutions

The benefits of data integration in education offer flexibility, economies of scale, and opportunities for enhanced student services. These benefits include data and safety benefits. The problems of using data include the effort required to integrate and manage the varied sources of data available so that in their native state they can use benefits. We verify that all of these problems should not be solved with a new column unless we give everyone a reason to ensure that all of the integrated data are correct. To show the error of the probability of emergence, verify the contact point using cleaning and the use of verification as antagonistic terms.

One of the key insights is that by using the session, the relative population distribution of the level of information usage of a commercially available solution for providing university education consortium data as a service was going to adhere to documentation and security standards for real-world regulatory measures as well as future regulations. This approach could be expected to increase the exploitation and management burdens of their integrated and personally governed data. Introducing innovation. For aspects of the context of available customized higher education, we also discuss our approach through some other challenges and financial, data management, technique, marketing, and recruitment assessments relevant to today's competitive challenges of higher education.

2.5.1. Implementing AI in Curriculum Development

The expert educator then coaches students who miss questions involving program selection, stating, "Each island has a different set of programs to choose from, which leads to a different best set of policies. The program selection will vary among the islands, and only part of the selections help solve a user's problem." Expert teachers have inductive biases about learning combinations of individual programs, which they pass to students. In the policy-making analogy of data analysis tools, the system expert helps gather information about which potential candidates are best suited to a certain task. The expert then induces decision-making patterns that help others construct good solutions based on who they are. These teacher and student roles can be developed by defining certain values for how information flows through categories related to program and student behavior. Such a framework provides a base for starting new lines of curriculum development. Explicitly defining the structure of a problem gives us the ability to recognize which models help solve which problems. With this insight, educational resources can be customized to help students optimize decisions related to their chosen areas of study, thereby identifying new, more sophisticated ways of thinking. The goal of AI research is to find adaptive systems that work at a high enough level to automate and explain the properties underlying everyday patterns of which humans are largely unaware.

2.5.2. Enhancing Student Engagement through Data

The higher education sector in many countries is under increasing pressure to respond to workforce skills gaps and rapidly advancing technological changes in education. Graduates' preparedness for work was ranked as the most pressing and least effectively addressed challenge. With competition among universities increasing regarding student satisfaction, employment rates, and student retention, universities have a major stake in these issues. However, an important part of the answer to these expectations lies in student and lecturer behavior and motivation, and in creating informed feedback loops for all those involved.

Quantified effectiveness, improved decision-making, and the capacity to monitor optimization are important measures for any sector but are difficult to achieve without verified data. It has been challenging to balance educational research resources and student academic loads without relying on a very low survey response rate and other feedback from students about their learning and teaching experiences. Universities can now use systems that provide protective anonymity and increased convenience for those providing data to enhance the university's capacity to compete for students misled by improvements in teaching and learning. Universities provide statistics on student satisfaction with their teaching as part of the annual survey. Because of the unique nature of their data set, universities publish two sets of satisfaction statistics.

2.5.3. Institutional Performance Metrics

In this section, we demonstrate the capability of the proposed EIFME architecture to transform institutional data from unstructured examination records into intelligent entities. The production records from one of the institutions used in the study were utilized in the benchmarking and performance evaluation. A total number of 33,733 students graduated from the university over a cumulative period of 7 years of the 10-year mark-production database, with a total of 1,525,883 data records. These include information on student examination results, with fields such as student name, courses attempted within a semester, and base course information provided. The performance metrics utilized in this demonstration include overall student performance metrics, semester-over-semester and year-over-year analysis, and performance against academic progression analysis. The results demonstrate a supervised approach to intelligent monitoring and analysis that is consistent with the exploration of big data in the education domain.

In the supervision component of the EIFME architecture, metrics are used to assess institutional performance and trending against the university's underlying environmental factors. Financial signals are selected and endorsed around institutional success, allowing classification between over- and under-performing institutions and ensuring prudent and informed decisions. Using this repository, institutions may concentrate their decisions around money in activity areas that most relate to the performance of the institution in the measurements. Signals are categorized into tuition fees, research, and state budget-based signals. It is important to evaluate these propositions in a way that respects causation as opposed to mere correlation. Data available in systems imply key attributes and others. When these data are employed, they produce correlations but do not equate causation. The EIFME will model the important interactions between attributes and is itself part of the large-scale model employed by the academic supervisors in each academic discipline at the higher education institution.

2.6. Case Studies in Renewable Energy Infrastructures

This section focuses on illustrating the benefits of connected intelligence in renewable energy infrastructures using two case studies. The first case study is related to power generation and focuses on optimizing the performance of solar power plants. The rise in solar plants being deployed during the last few years has gone hand in hand with the technological advances achieved in solar panel production. The use of IoT solutions tailored for optimizing the performance of these plants is a natural next step in this evolution. One of the main technological setbacks faced by the teams in charge of controlling and optimizing the correct operation of solar power plants in Spain is the lack of intelligence on the substations that connect the different plant elements and the control room to the information received. Unlike the existing use of similes in control panels, the substations of the Spanish solar power plants installed lack any kind of intelligence. The electrical parameters that directly affect the generation of energy by the plant and the cloud cover are the intensity of the generated energy and the angle of incline of the panels based on the sun. The importance of intensity will depend on the performance of the solar panels to determine the maximum electric power that a solar panel can deliver for different levels of sunlight. When the sunlight is stronger, it offers its maximum value. The map shows where a certain amount of hours is presented. The case study was carried out at the site of the photovoltaic plant in Puerto del Rosario - Salinas de Antigua. The plant has a capacity of 1 MW, 113 inverters, and is located at an average altitude of 60 m above sea level.

2.6.1. Real-Time Monitoring Systems

Education, one of the largest sectors around the world in terms of workforce size, spending, and facilities, significantly contributes to national economic output. Despite sizable financial and human resources and advanced technology in some areas, many students believe the current education system fails them, particularly in creating a unique, memorable experience. Educational leaders need to be disciplined in creating innovative and scalable business models so that students have a transformative learning experience. Educational institutes need to redefine their value proposition, making sure that students and professionals do not forget their experiences therein. Educational institutes should reinvent every element so that they are seen as the epicenter of connecting students and professionals to a future that is vivid, dynamic, and, most importantly, uses technology similarly to the way the students do.

Leveraging business intelligence for decision-making in educational leadership is not a futuristic notion anymore; it is a necessity. This is supported by the fact that many managers of leading educational institutes recognize that better decision-making, based on more data, is the most critical growth factor in gaining advantages. There are only a few applications that illustrate a real-world advantage of business analytics for enhanced decision-making within education, to be used by educational leaders. This study introduces and describes a near real-time monitoring system that aims at observing the students' interactions and behaviors in an online communication setting using machine learning algorithms. Data is collected from a virtual campus, established in a simulator, hosted on campus servers, and managed by the security team. Data collected are the dates and times of all logins and logouts, the IP addresses from which the log-in and log-out actions were taken, and the avatar names, in addition to their associated names of senders or recipients of all in-world messages including chat.

2.6.2. Optimization of Resource Allocation

As demonstrated, the maximization potential of optimizing resource allocation is massive. In the context of education, the key resources are the students, teachers, the curricular content, and the delivery infrastructure, while concerning renewable energy, the assets are the amount and type of energy generation facets and the energy storage capabilities. These resources need to be allocated optimally to maximize the functioning of the social system. We demonstrate that this challenging optimization can be effectively handled by appropriately leveraging the powers of connected intelligence.

The problem of optimizing the resource allocation for education is, in general, a very difficult one. However, the set of challenges can be narrowed down by focusing on a set of key priorities essential for student growth and happiness. A proper allocation of a child's capabilities would be one of the most efficient ways of promoting talent. The success of gifted education programs is, in turn, directly related to the availability of teachers to cater to student needs. The success of educational content is enhanced by a good fit of content matching. Each child's education is a highly individualized outcome, as it is developed based on innumerable combinations of student, school, family, community, and state biases.

2.6.3. Impact of IoT on Energy Efficiency

IoT generally covers the set of technologies and interconnected objects or sensors, apart from those traditionally considered Internet-based. These often consist of RFID, routers, cameras, light sensors, touchscreen panels, and many others, all of which can be accessed through a computer or a smartphone. The IoT has been an incredible facilitator in various areas, including smart cities and healthcare. It has made significant strides in the field of energy, leading to the smart grid and irrevocably changing the energy efficiency of buildings and the utilization of transportation systems in entire urban areas. Energy efficiency can be considered a key engine for achieving the goal of sustainable development in modern society. Understanding energy efficiency as doing more with less, consumer electronics are required to perform more complex tasks at an increasing level of product and service quality while requiring less energy. This can also be linked to our role as managers of energy, enabling the development of more sustainable cities and infrastructure. The Internet of Things (IoT) offers a fertile environment to make this possible due to the massive use of intelligent equipment that permeates the areas of attention managed in our daily lives. Energy has economic value and scalability. Efficient and economical use will determine who will meet our demand, and the price will be established. To this end, IoT is a key technology because it supports us in reacting positively to the unexpected if it occurs and in planning predictably when it can be done. The effective control loop implies a loop of action and a loop of learning. Both imply a system capable of understanding its procedures; the usual term is 'intelligence.'

2.7. Challenges and Barriers

Another limit in enhancing our education systems could be found in the global presence of outdated cultures, laws, and mentalities across countries and institutions. There still are contemporary and outdated countries where state and religion do not seem to leave room for dialogue and negotiation for further development, economic and ethical distribution, and peaceful coexistence between increasingly soft and interdependent national systems. Despite global education, a myriad of self-referential or imposed laws and cultures are preserving in time students' expectations, attitudes, and approaches to learning. Therefore, education may be less meritorious than it would deserve in the dissemination and updating of knowledge and interpretation, in the promotion of active and shared responsibility. Indeed, in the presence of continuous threats towards climate, economy, and civil coexistence, education, whilst perfecting knowledge and abilities, resources, and interests, should effectively and strategically project human systems towards current and future global challenges.

Renewable energies remain the object of preconceptions and disinterest. Their sudden diffusion and the implicit overturning of the energy dogma have violated the equilibrium and share-out of politics and markets controlled by coal, oil, and gas. This is why the destitution of fossil sources is proceeding in conjunction with frequent experimental technological demonstrations. Moreover, difficult economic and environmental change renovations are complicating the procedures. Plurivalent opposed situations, reinforced by contrasting economic and development analysis studies, still condition political expediencies and long-term agreements. Rather than stimulating the replacement of exhausted sources, strategies appear to address the reduction of renewables, remaining, whenever possible, more eco-compatible.

2.7.1. Data Privacy and Security Concerns

In connected intelligence research and applications such as those presented, one must address data privacy not solely through generally prudent technical and policy measures but also at times through especially creative and principled methods to share public-spirited analytics. Systems with confidential internality akin to neural network models for privacy-preserving disclosure are of interest. Techniques to impose structure may to some degree support privacy-preserving disclosure during the learning of weighted predictions on basis functions in dictionaries or overcomplete representations.

At least when also designating member associations or groupings, the widespread effectiveness of machine learning techniques can create enforceable fair chance concerns for the use of certain technologies. Specifically, trade secret considerations do not usually limit academic research but, under rules of common conduct, do protect the knowledge assets of what are typically powerful business interests. To allay trade secrets or other misappropriation concerns regarding provable partial reversibility in differential privacy work, presented machine learning methods should be adapted to implement protected computations for corporate contractors and clients in a prudent and practicable manner.

2.7.2. Integration with Existing Systems

It should be noted that there is a significant distinction between IMS conformant systems and the fusion of multiple unrelated systems. In the former case, the IMS can define a common model for the formation of data collection, data storage, and communication. In practice, this will be most useful when different institutions or vendors develop application-specific versions of collection interfaces. Another application of this is in high-end learning management systems. Learning management systems typically offer a wide range of data collection capabilities themselves and wrap multiple e-learning components. In the cases where these are not sufficient or are missing, vendors will create plug-ins and application-specific interfaces to fill the void.

IMS conformant systems can then build off of the communications model in the learning management system. Vendors of major learning management systems in the market today are active participants in the activities to create a standardized model for what information these components need and expect in terms of information delivery. There are several difficulties in simply extending centralized learning management systems for large groups of content and component providers, however. First, most large systems are typically not designed for peak capacity for their components. Their structure reduces scalability and may limit some architectural choices at the outset. Centralized systems tend to define centralized user identities, and those identities do not automatically translate across multiple employers or educational institutions. Finally, there are a variety of privacy issues and export regulations that may come into play, which can greatly complicate the offering of educational services from a single centralize.

Universities and companies are, in many ways, fairly similar. They are both bureaucratic forms of organization. They have similar work environments; both are ruled by a faculty that has prioritized job security. New missions or new methods challenge conventional methods and responsibilities, dilute institutional identities, and redistribute available rewards. Such changes not only challenge the entrenched dinosaurs but also the extent to which such innovative leaders are a threat to many of their peers. Most advances in higher education over the last five centuries have resulted from sudden sharp breaks. More often than not, it is small private institutions or small departments of larger organizations, discoveries, and developments in not-for-profit research and teaching organizations, piloting some new method, concept, or practice.

2.8. Future Trends in Connected Intelligence

From Smart to Connected Intelligence: A Future Trend Considering the pace at which artificial intelligence is developing and being mainstreamed, a near-future transformation from smart to connected intelligence is upon us. The concept of connected intelligence would be defined by digital systems and data platforms' ability to process structured and unstructured information from new and multiple sources in real-time. Connected intelligence will enable the system to discern patterns and allow autonomous actions to be reviewed and validated with relative ease. Just like the initiation of intelligent automation and extreme personalization, this future state of connected intelligence would bring enhanced insight discovery and decision support. In terms of contemplating the future of connected intelligence and society's readiness, five horizons that dictate the evolution rate of connected intelligence are: today, near, mid-term, long-term, and far future. Although transformative, many benefits may not be immediately realized, causing a slower pace of connected intelligence than anticipated. The mid-term horizon posits a return to privacy and social engagement, while the long-term and far-future horizons reflect the evolution of new industries and larger societal changes as connected intelligence becomes increasingly integrated into our day-to-day lives.

2.8.1. Emerging Technologies

The concept of connected intelligence through wireless connectivity will continue to evolve in areas such as human-computer and machine-to-machine communication, as well as the data collection, storage, and analysis of wireless sensor networks. WSN nodes, which use low-power microprocessors and utilize wireless communications for sensing changes in the environment and then communicating these changes to a remote computer or mobile terminal instead of a human, have been around for over a decade. RFID tags, which were developed to replace the barcodes of supermarket items, are already widespread, though they have not diffused fully into other areas such as shopkeeping and warehouses as initially envisioned, mostly because of cost. What we are now seeing is the blurring of the line between passive RFID and WSN, with units combining both passive and local computation capabilities along with wireless communication, making them somewhat similar to WSN nodes.

Carbon nanotubes and graphene may have a major impact on electronics, energy storage, harvesting, and sensors. CNTs are very strong and have high electrical conductivity, high thermal conductivity, and small size, but with the world's current technology, they would be prohibitively expensive. While examples of WSN and RFID can be found today, connected intelligence is in the very limited deployment stage. What is known about technology diffusion is that there are people who quickly adopt technology and are called innovators or early adopters, and there are those who are slower and are called the early and late majority. The balance of the population falls into the category of non-adopters. Wireless sensor networks are for the innovators. Smart dust, the concept of tiny wireless communication nodes, is still a gleam in the eye of researchers.

2.8.2. Policy and Regulatory Considerations

As critical enablers in every national context, policy, and regulatory frameworks must also evolve to incentivize data sharing and resource collaboration, enforce data and decision quality, and develop institutions to promote the value of connected intelligence. These institutional and governance reforms are essential for all nations, especially in developing countries, as they seek to unlock, harness, and create value from the data that is and could be, available for speeding equitable growth and achieving better life outcomes. Whether questions revolve around trade-offs between equity and efficiency, freedom and order, empowerment and consumer protection, or rights and responsibilities, the concerns with privacy, protection, and valorization of individually and collectively generated data should inform the design of public policy.

When institutional structures can harness the strengths of privacy protection and expanded data sharing for social good, they can rescale the value of data to accelerate equitable growth. A well-designed digital public space invites all to participate, grow, and thrive. In this venture, properly constructed policy can leverage the enhanced effectiveness of enabling institutions and governance to promote connected intelligence. Policymakers also require appropriate measures to address the challenges posed by digitalization, the Internet of Things, big data, machine learning, and ethnography. Circuit breakers are good examples. Separating threats from opportunities is essential unless the policy wants to close the internet. An abused person might request a temporary opt-out, as can a treaty being confirmed, or a healthcare request being finalized. An emergency opt-out might also be used in traumatic events rationalizing market meltdown.

2.8.3. Potential for Global Impact

Connectivity is a game changer. It has massive potential for education and renewable energy. Education is a key instrument for pulling societies out of poverty as well as an important accelerator for countries wanting to take part in a high-value global economy. Linking educational institutions through digital channels allows students, schools, and universities easier access to courses, best-in-class teaching, international collaboration, and advanced learning materials. Renewable energy means economic and resource liberation in addition to pollution-free energy. Its relentless advancement causes ripples in how we look at and use energy in general; beneficial change is not limited to the impact on oil prices. Renewable energy is essential for combating the effects of burning fossil fuels on climate change as well. The immediate and beneficial local effects of the exploitation of renewable energy are cleaner air, uncrowded soundscapes, and unpolluted water.

The comparison of actual data available through the networks and digitally formalized events with decision-making processes will improve the outcomes of our decisions in education and renewable energy: in building a digital human future, fostering the non-discrimination of knowledge is a prioritized social goal. The priority of this goal has been reflected in the development of the IT infrastructure, which has transformed billions of internet users and mobile users into digital humans. Subjective input has been minimized at the digital communication level; the decision-making processes are weighed on objective reality. Education and renewable energy are two examples in which connected intelligence can accelerate learning and growth, possibly due to knowledge and technologies that digital access permits, and the complete elimination of the scarcity barriers that have held us back.

Fig 2 . 3 : Connectivity as a Game Changer: Impact on Education & Renewable Energy

2.9. Best Practices for Implementation

To achieve its huge potential for good in the world, the management information systems community needs to demonstrate in solid pilot applications the kinds of powerful decision-support tools that the technology is capable of providing. The challenge is to demonstrate the development of educational decision support applications that are as exciting as other advanced products. Only in this way can the public investment in management information systems technology bear fruit for large areas such as education, transportation, and criminal justice that have yet to realize their potential.

Implementation Guidelines 1. Advocate a broad user community for educational management information systems. There is a risk that, given the pressure to demonstrate a return on investment, MIS projects will emphasize only those features that can be readily shown to save time or money.

2.9.1. Strategic Planning and Roadmapping

Strategic planning of smart education and pure engineering departments, i.e., planning the distribution of degrees among traditional and smart students that follows a certain forecast, can be considered a very important managerial decision, the success of which largely determines the success of the university in most other areas. In some universities, the demand for a central distributed learning course, from the point of view of the number of returning students, adequately represents the existing one. However, it can be argued that this current demand, in any case, largely represents an important part of future measurable or realized demand among the rest of the potential students. By this vision, it is proposed to consider the modeling of the selection course offered by the university as one of the most important indicators of the university's strategy in attracting students and the observance of the necessary capabilities.

Thus, when developing software by educational institutions that want to track compliance in educational activities with the influence of a specific professional environment, in addition to the formal criteria of objects, it is possible to consider the most relevant thematic classes. At the same time, as a component for estimating the subject area of the environment that specialists are developing at educational institutions, it is possible to use geographical and property characteristics. Note that in educational institutions, the availability of information on the demand of students for obtaining educational courses, a model of the material appetite of a specialist, is moderate. This allows us to consider the relevance of the uniform computing environment as one of the important criteria that must be tracked when selecting the subset of the GIS server functionality and using it with the service provided to the selected category of specialists. At the same time, the maximum number of respondents can be used with the most rational use of educational institutions for the implementation of relevant lectures, measuring the physical potential of society with the ability to obtain professions of a specific profile.

2.9.2. Stakeholder Engagement

Engaging stakeholders from diverse backgrounds can provide unique perspectives to complex problems, further diversifying and deepening the potential of connected intelligence through unique organizational knowledge and culture. Stakeholder engagement is a communication process that includes dialogue among stakeholders before critical decision-making, as well as information sharing and education. Engagement fosters accountability, transparency, credibility, and legitimacy and can contribute to outcomes such as successfully implemented and effective public policies, programs, or practices. It is different from public outreach, in which information and opportunities for feedback are provided by an organization, but there is no expectation of changing or influencing the decision-making process based on the feedback. Public input from stakeholders can be critically important to the successful selection of renewable energy projects for research to ensure that a wide range of project types and geographies are included and to support specific objectives of public stakeholders, such as increasing the availability of renewable energy options in public buildings or specific locations.

A well-structured engagement program for problem-solving can have additional strategic value. First, building a community of stakeholders that a company understands intimately and engages with continuously is simply good business practice. Second, insights from external stakeholders on services, products, markets, resources, and competition can better inform company strategies. Finally, successfully engaging external stakeholders in corporate innovative activity can enhance the public's appreciation of the company's good citizenship and responsiveness as a corporate neighbor.

2.9.3. Continuous Improvement and Adaptation

Good use of connected intelligence is continuous "pointing" and clustering. As we apply the power of the intelligent feedback we get from all the data connections, there will be progress. We will be doing things more accurately, efficiently, and effectively. But there is more. No matter how advanced the current set of reality perceptions or decision rules are, as long as we have not reached 1.0, we will keep getting feedback pointing out mistakes, flaws, and underperformance. That is why the process involved intense "pointing" – so that significant further progress can be made. The continual feedback and learning will foster continuous adaptation. Continual adaptation, or agile development, means people using the CI processes get on the right path. They make a "course correction." They continually take in feedback and apply that feedback in their analysis and decision-making activities. Then they get further alignment between what they are doing and better reality performance. We are likely to be happier taking part in a process when we know how to do that. Whether we are teachers, entrepreneurs, or members of other professional groups, we can make decisions that lead to substantial improvements when we know more about how to develop and adapt.

2.10. Conclusion

The purpose of this chapter was to look at ongoing research work in the areas of education and renewable energy to gauge whether connected intelligence is being effectively leveraged for decision-making. The use of technology in the form of artificial intelligence, big data, the Internet of Things, and a host of other data collection, monitoring, and other tools is becoming essential. Whereas we may have reached data-critical mass and thereby taken a first step in the transition from excessive information to potentially enhanced intelligence, many areas still need to be addressed, and the clock is ticking.

Time is the one factor that is rapidly slipping away from all stakeholders in the education system in Nigeria. We argue that the sheer volume of human intelligence that is being connected offers researchers in this and other areas overwhelming new ways to process such connected intelligence to shed light on its structure and critical features. With additional investment in connected data for this sector, it will also be possible for other agencies and decision-makers within and outside of the sector, including policymakers, development partners, students, and the general public to join in this growing movement that leverages connected intelligence to transform both the education sector and the renewable energy sector.

2.10.1. Key Takeaways and Implications for the Future

This chapter presents a case study utilizing an advanced campus Energy Management Information System (EMIS) to provide a data-driven approach to support facility management decision-making, while also providing useful learning experiences for a next-generation building professional workforce. The study uses building performance data from seven university residence halls and aims to understand how these data can be used to support energy managers in meeting sustainability goals, in the unique context of energy use in student housing. This case study also details the development of a classroom learning module where undergraduate students from different disciplines worked together to compare approaches for the energy-efficient operation of these buildings.

Leveraging connected intelligence in higher education institutions extends state-of-the-art utility data tracking and processing platforms capable of promoting transparency, stimulating competition towards more ambitious performance goals, and enhancing script generation and sharing with real-world examples. This creates a stronger connection between curricular and hands-on activities, increasing the relevance of educational programs. The classroom materials and engagement opportunities that are designed provide mechanisms to recruit potential entrants to the building management field, encourage exploration of technical and behavioral contributions to climate action, and help prepare a future workforce capable of handling real-world sustainable building challenges. Additionally, the project suggests that building performance data, autonomously corrected for sensor drift and system malfunctions, can be employed to observe trends in student behaviors such as meal utilization, social event impact on thermal comfort, and bed length disparities as well as impacts of new appliance installation.

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