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Application of Wireless Sensors in the Design of Smart Learning of the English Language Utilizing Zigbee Network Technology

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Abstract

In conventional English classroom instruction, students' learning effectiveness is often affected by various factors, including the classroom setting, individual student circumstances, and the teaching methods employed by instructors. The paper develops an efficient Smart Learning of English Language (SL-EL) system utilizing ZigBee (ZB) technology. This paper enhances the conventional ZB algorithm and develops an SL-EL system utilizing ZB Wireless Sensor Networks (WSN). This paper enhances the prediction algorithm for determining students' precise locations and orientations on the school's premises, examines the SL-EL system's network architecture according to SL's actual requirements, and establishes a three-tier instructional and educational system. This paper establishes system function units based on demand estimation, examines the data analyzing the efficacy of the network nodes within the SL through empirical investigation, and assesses the system's EL learning outcomes. This paper employs simulation methods to analyze 81 data points

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to assess the ZB network's data-analyzing efficacy. The results indicate that implementing the SL-EL system utilizing the ZB network enables teachers to more effectively manage changes in the classroom setting, monitor students' engagement, and address other constraining factors to enhance teaching and learning effectiveness.

Keywords: Smart Learning, English Language, ZigBee, Wireless Sensor Networks.

1 Introduction

Artificial intelligence (AI) systems are causing significant transformations across nearly all sectors of society. In conventional classrooms, students' educational effectiveness is significantly affected by the environment, instructional methods, and individual circumstances (Gruetzemacher & Whittlestone, 2022). For example, when the classroom is excessively hot, students are prone to restlessness and cannot concentrate. Subsequently, an individual is expected to activate the air conditioner and regulate the room temperature. Furthermore, when the classroom is poorly illuminated, students may be unable to comprehend the notes on the chalkboard. Someone must activate the lights in the classroom. Nevertheless, if educators manually control the classroom technology to create a suitable learning environment, the advancement of education will be hindered (Sulochana, 2020).

Moreover, for numerous universities and colleges, particularly in English courses with large enrollments, managing student data and manually tracking attendance is time-consuming and energy-draining for educators, hindering their ability to recognize and recall students' features (Huércano, 2021). Logs of attendance represent another matter that educators should prioritize. The conventional attendance system faces challenges as it is crucial to expedite decision-making processes and reduce the likelihood of failure. Implementing attendance systems utilizing WSN technology will enhance teachers' ability to manage their students in the classroom effectively.

The existing issue is that student attendance tracking is still partially conducted manually. Consequently, educators must allocate significant time to ascertain the attendance of all students. Alongside confirming teachers' attendance, they occasionally provide a pupil attendance sheet to the students. This could squander students' educational time. Signing errors often occur, and absent students may request their friends to assist in updating their attendance (Yin et al., 2021). Educational institutions, including colleges and universities, should implement comprehensive Internet coverage for all courses and transition to an automated attendance system (Habib et al., 2021).

The efficacy of students' education is significantly influenced by various external environmental factors, including their educational environment, students' circumstances, and the pedagogical approach of the instructors (Brink et al., 2021). This paper aims to evaluate and suggest a novel teaching model that integrates multidisciplinary technology, specifically WSN technology, to enhance the involvement of teachers and students in the classroom (Chan, 2018). The implementation of an SL management system is essential to enhance the effectiveness of EL. Implementing an SL in higher education can enhance the current teaching model and facilitate advances in technology, administrative innovation, pedagogical reform, innovative services, and lifestyle innovation (Yolvi et al., 2023). The SL system can concurrently enhance processing efficiency.

The advancement of SL and intelligent campuses in Uzbekistan has yielded notable outcomes. Numerous technical and scientific scholars, teachers, and pertinent national policies have significantly contributed to advancing Uzbekistan's education, substantially enhancing the information technology standards within the national education system (Alisher o'g'li, 2020; Yin et al., 2021). In the 1980s, when networking technology for computers was first developed, Uzbekistan had not yet established an extensive knowledge of SL campuses (Hu, 2018). Most campus educational and instructional activities relied on human resources during that period. Furthermore, the occupancy rate of educational tools is exceedingly low, hindering the sharing of essential resources such as SL materials, teaching aids, and technological assets (Arasu et al., 2024).

2 Bibliometric Analysis

As global interaction regarding social, conventional, and technological frameworks expands, along with the extensive networks facilitating this exchange, states can choose which developmental aspects they wish to replicate. Scholars often engage with a notion of globalization encompassing the major societal, cultural, economic, and interpersonal technological transformations occurring globally today (Agbo et al., 2022). Recent communication and information technology advancements have brought all nations, individuals, and civilizations into unavoidable proximity (Al-Bukhari & Shehata, 2018).

Globalization possesses both advantageous and detrimental facets. It corroborates the prevailing hypothesis that globalization facilitates significantly enhanced economic growth through its fundamental frameworks and potential to augment interdependence, unity, and interaction among nations and enterprises (Chang, 2018). Globalization catalyzes commerce, enhancing prosperity and elevating the quality of life in the South (developing nations) while generating wealth in the North (developed nations).

Global civilization, often called globalization, has become pervasive, characteristic, and enduring (Sassen, 2020). The accelerating pace surpasses the capabilities of nation-states, especially in the Global South. In contrasting globalization and its impact on societies, we must reassess the objectives of national academic policies and improvements in the present era. This framework indicates that the existing educational reform model, especially in developing countries like Kazakhstan, suggests a shift away from addressing national requirements. Reforms have relied on academic funding, highlighting selective education-related trends best comprehended through comparable aspirations to align with developed nations (Robertson & Dale, 2020). Consequently, recent educational financing reflects the growing inclination of developing nations like Kazakhstan to emphasize the socio-cultural attributes of developed countries rather than solely adapting to alterations in their material and socio-cultural contexts (Karami Akkary, 2014). The perspective on development includes achieving parity with developed nations by emulating the characteristics of esteemed national societies (Llopiz-Guerra et al., 2024).

Teachers do not solely oversee the classroom in contemporary society; it should be managed more efficiently. Machine learning (ML) employs parameter training algorithms to effectively identify the environmental conditions within a classroom and manage the classroom atmosphere (Yağcı, 2022). The classroom technology should be modified to ensure learners are comfortable and should not impede their learning (Doris et al., 2023). Consequently, developing a real-time classroom surveillance system is imperative, and numerous design schemes exist to address this issue. Regardless of the strategy employed, the objective is to enhance students' knowledge acquisition. These systems should be optimized for enhanced applicability to students' studies. The development of this technology frequently requires several days or weeks to finalize, encompassing various technologies and certain digital processing methods.

Numerous universities have already established diverse sports facilities for students, faculty, and staff (Mercer-Mapstone & Bovill, 2020). However, the number of students exceeds the capacity of the facilities for simultaneous use. The students and educators must sequentially await their turn to utilize the facilities. Individuals require adequate exercise, yet few people have access to an expert trainer to instruct them on proper techniques. Consequently, a classroom administration system equipped with WSN can oversee the facilities for students and teachers. Likewise, these datasets provide a range of distinct ML methodologies with varying capabilities. The study of ML has two primary objectives. The initial objective is to assess the validity of temporal and process-level data and conventional indicators concerning ML forecasting algorithms. The second objective is to ascertain whether the type of ML technology employed influences forecasting outcomes in a classroom setting that utilizes computer-based information (Yeung et al., 2021).

WSNs are extensively utilized across various domains, including armed forces, farming, healthcare, and mining. The rise in the frequency of users has augmented data transmission and enhanced convenience in daily life. Consequently, the Federal Communications Commission (FCC) has instituted particular regulations and limitations due to numerous applications. This constraint results in a spectrum deficiency. Much research is being conducted to identify the optimal solution to the frequency shortage issue. The main consumer is the licensed individual, while the additional user lacks a permit to access the radio spectrum (Saha, 2021). Licensed users can utilize this spectrum segment for data transmission and reception, while unauthorized users are prohibited from accessing these portions, regardless of occupancy status (Odilov, 2024).

The authors in (Li, 2021) integrated information technology and WSN to develop an SL campus system, evaluated its effectiveness through simulations and ultimately validated the results with real-world proof. The research findings indicate that the developed SL system is highly viable. The literature (Gao, 2022) integrated WSN with Internet of Things (IoT) technology to evaluate all campus functional areas, developed an educational SL system and a safety system, established the notion of SL, and achieved notable outcomes. Conventional algorithms exhibit issues, including inadequate positioning precision and diminished resource processing effectiveness. The proposed framework presented in this paper can optimize the SL campus's positioning efficacy while incorporating teaching suggestions and additional functionalities that can significantly enhance the educational and managerial outcomes of the SL campus.

3 Materials and Methods

The paper presents an algorithm for WSN nodes that enhances the processing of educational resources, increases transmission effectiveness, and diversifies transmission pathways. Sensor components are frequently utilized in various intelligent mobile devices. The proliferation of smart terminal systems has facilitated the advancement of location technology utilizing WSN components within these devices. There are presently two categories of campus localization techniques utilizing WSN. One method relies on sensor positioning, incorporating velocity and angular information through double integration. The alternative is a trajectory computation algorithm that identifies and computes the student's positional data based on the student's specific movements.

The path calculation method is the predominant tracking technology utilized in campus navigation. Tracking calculation involves commencing from a known location, traversing for a specified duration, and determining the location coordinates of the present location based on the distance and course traveled during that interval relative to the dimensions of the preceding location. As illustrated in Fig. 1, the student is positioned at the coordinates $(X0, Y0)$ at $T0$, designated as the initial coordinates. Between $T0$ and $T1$, the student traverses a distance $d0$ in direction a to arrive at position $(X1, Y1)$. Subsequently, the student traverses a distance $d1$ in the direction b from $T1$ to $T2$, arriving at the coordinates $(X2, Y2)$. Ultimately, the student traverses a distance $d2$ in the direction c from $T2$ to $T3$ to arrive at position

$(X3, Y3)$. From the example mentioned above, it is evident that the student's trajectory computation from $T2\ to\ T3$ adheres to the equation (1, 2) given below:

$$X3 = X2 + d2 * sin\gamma \quad (1)$$

$$Y3 = Y2 + d2 * cos\gamma \quad (2)$$

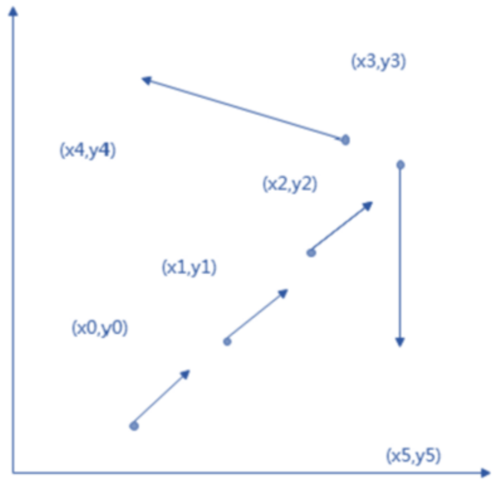


Figure 1: Path Forecasting Algorithm [20]

A linear correlation exists between the EL learner's stride length and frequency. The forecasting method typically relies on the preceding step of the forecasted step in conjunction with the mean value for estimation. The reliability of path computation is primarily influenced by the precision of the preliminary coordinates, the precision of the strolling distance, and the correctness of the track. The distance is calculated by multiplying the number of steps traveled by the learner by the EL learner's step length. The geographical coordinates of the subsequent step are determined based on the student's path of travel. The path and total number of steps the learner takes can be determined from the recorded data of the velocity sensor. At the same time, the student's travel orientation can be ascertained using the gyroscope or digital compass. Nonetheless, the sensor data cannot directly determine the student's stride length. The learner's random stroll will result in accumulated errors from the specific route calculation algorithm, increasing over time.

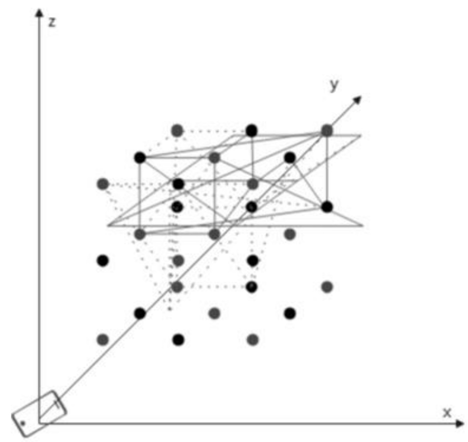
In real-world scenarios, the geographic coordinates of the mobile phone differ from that of the student's location, necessitating the conversion of angle data from the mobile phone's location system to the plane geographic coordinates. Establish the positioning system for the student's MCS. When a human being is ambulating, establish a 3-D ground coordinate system, designating a vertical axis transverse to the plane as the Z axis, oriented upwards. At the same time, the axes parallel to the ground conform to the left-hand rule. Fig. 2 illustrates the phone location system comprising the x, y, and z axes. In the mobile positioning system, the x-axis extends to the device's right edge, the y-axis ascends along the phone's surface, and the z-axis rises perpendicularly to the device's plane.

In the present study, certain investigate methodologies necessitate positioning the mobile phone in a vertical or horizontal position to circumvent issues related to coordinate scheme translation. Certain studies have converted the angle information from the mobile phone location system into the learner's movement coordinate system (MCS) via matrix solution transformation. The initial method is inadequate for practical uses, as learners cannot ensure the mobile phone remains stationary while walking. The subsequent method exhibits significant computational difficulty, and the correlation between the mobile phone dimensions and the EL learner's MCS will also vary with movement. This work outlines the procedure for projecting the angle obtained from the mobile device into the student MCS through the following phases. The initial phase involves double-integrating the angular velocity using the specified formula to derive the angular information for the three axes. The equation (3-5) given below:

$$\theta x = \iint_{t-1}^{t} \omega x dt \quad (3)$$

$$\theta y = \iint_{t-1}^{t} \omega y dt \quad (4)$$

$$\theta z = \iint_{t-1}^{t} \omega z dt \quad (5)$$



Figurer 2: Mobile Phone Location System [20]

The next phase is ascertaining whether the student is engaged in linear movement. The linear movement threshold is established at 10 in this paper. If the three-axis angle remains below the established limit during time t, the EL learner is deemed to be moving linearly, prompting the algorithm to revert to the initial step; otherwise, it advances to the third phase. The third stage involves projecting the angle of the mobile phone's MCS onto the Z-axis corresponding to the learner's direction of motion. In the fourth stage, a mean filter is employed to refine the angle once the angle data has been calculated. A mean filter with a window dimension of 30 sampling intervals processes the acquired EL learner's movement direction, eliminating unwanted intrusion and yielding a flat curve. This paper outlines the methodology for calculating the trajectory and angle of a student's MCS. Utilizing a gyroscope-based algorithm entails low complexity; however, it requires an initial directional input and incurs a degree of cumulative error, necessitating supplementary algorithms for correction.

ZB technology is a developing network characterized by short-range, simple, low power consumption, low transmission rate, and an inexpensive network. ZB devices comprise three categories: managers, routers, and terminal nodes. ZB technology facilitates star, tree, and mesh network configurations. The protocol stack of ZB contains four levels: physical layer, data link layer, network layer, and application layer. It is a streamlined representation of the Open Standard Interconnect (OSI) architecture. The system employs a B/S architecture, utilizing the geographical database PostgreSQL to store spatial information and characteristic table structures. At the same time, ArcGIS Server facilitates the dissemination of map information and establishes the link between the client and server.

The paper employs a WSN to develop the educational system. The EL learning management data solution encompasses two roles: teacher and learner. Teachers of EL have functional modules that include publishing instructional content, releasing digital classrooms, distributing and reviewing course assignments, evaluating learners' progress, and accessing learner records. Learners possess useful features that encompass downloading instructional resources, engaging in EL classroom instruction, accessing and contributing in academic tasks, observing fundamental information about teachers, and additional functional elements. SL-EL system encompasses both implicit and explicit recommendation services. Implicit recommendation refers to the system's provision of the pertinent sources to the user based on the analytical outcomes of the SL framework during their search for resources. Explicit recommendation refers to the system suggesting pertinent resources to the user while they browse rather than the user directly acquiring resources.

4 Results and Discussion

This article evaluated the outcomes of the online survey to assess the identification and fulfillment levels of the SL-EL system in Uzbek. The research concludes that the SL-EL system enhances students' learning effectiveness based on feedback from learners and instructors.

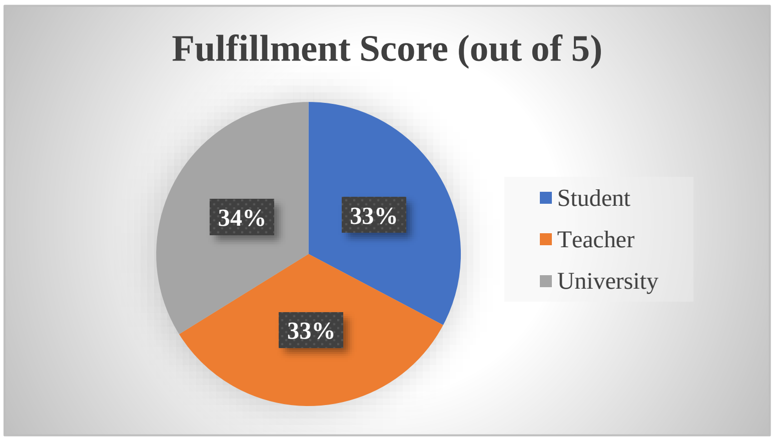


Figure 3: Comparison of Fulfillment Score

Fig. 3 illustrates that Uzbek students, teachers, and the university express considerable satisfaction with the proposed SL-EL system using the ZB-WSN network. Consequently, it can be inferred that this system is feasible and beneficial, making it suitable for implementation in SL-EL classrooms.

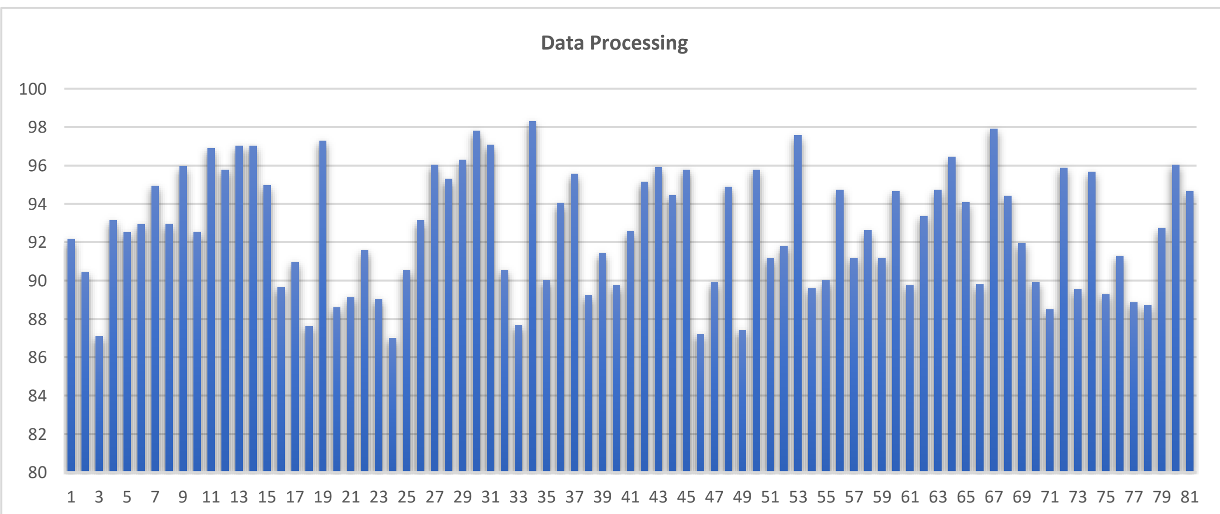


Figure 4: Impact of Information Processing in a ZB WSN for SL-EL

The efficiency of the system must now be analyzed based on the ZB-WSN. The current situation necessitates the development of a system of practical teaching to transform the conventional teaching model. The research investigation initially examined the information processing efficacy of the SL-EL system. The paper employs Matlab simulation to evaluate 81 data points and assess the information processing efficacy of the ZB-WSN, with the precision of the information processing estimated at 1%. The findings are presented in Fig. 4. Based on the analysis of the chart mentioned above, the ZB-WSN demonstrates a notable efficacy in information processing. This paper assesses the efficacy of the teaching process in the SL-EL system, illustrated in Fig. 5.

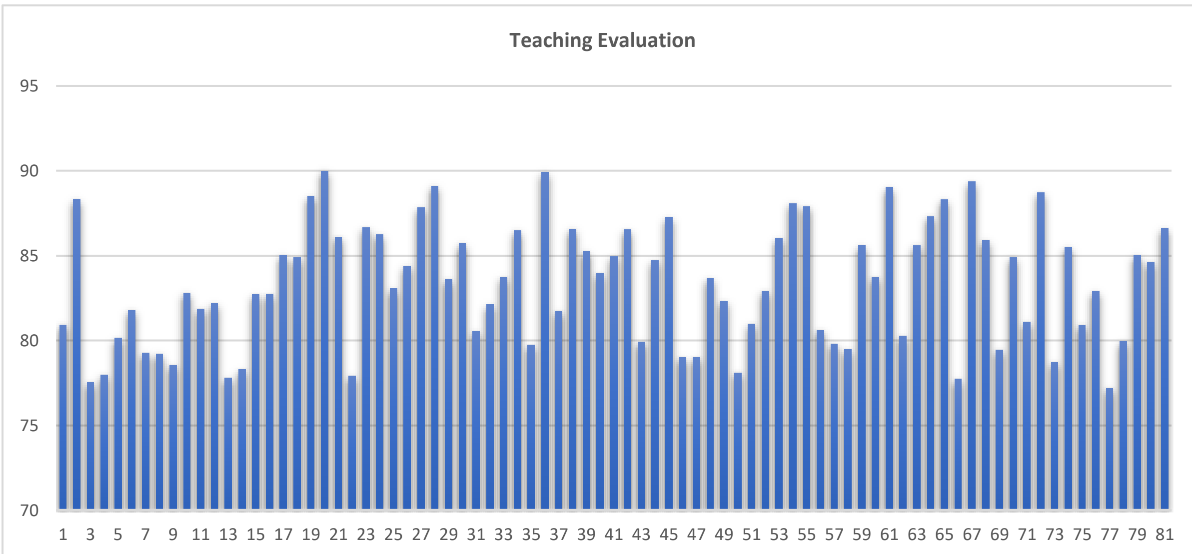


Figure 5: Impact of Teaching Assessment in a ZB WSN for SL-EL

This paper enhances the forecasting algorithm for determining students' precise position and orientation on campus, examines the network architecture of the SL-EL system following the actual requirements of smart education, and establishes a teaching framework. It further examines the information processing efficacy of the WSN nodes within this SL through exploratory research and assesses the teaching effectiveness of the framework. The analysis of the results above indicates that the SL-EL system, founded on the ZB-WSN developed in this paper, demonstrates a commendable teaching impact and is suitable for demonstration purposes in future applications.

In contrast to the conventional instructional model, the SL-EL model presented in this work is learner-focused, transforming the teacher-focused approach while enhancing resource gathering and effectively improving the teaching pace. In contrast to conventional pedagogy, the instructional approach advocated in this article has undergone significant enhancements.

5 Conclusion

The paper presents an effective Smart Learning of the English Language (SL-EL) system employing ZB technology. This paper improves the traditional ZB algorithm and creates an SL-EL system using ZB-WSN. This paper improves the prediction algorithm for accurately determining students' locations and orientations within the school, analyzes the SL-EL system's network architecture based on SL's actual requirements, and establishes a three-tier instructional and educational framework. The research investigation initially examined the information processing efficacy of the SL-EL system. The paper employs Matlab simulation to evaluate 81 data points and assess the information processing efficacy of the ZB-WSN, with the precision of the information processing estimated at 1%. In contrast to the conventional instructional model, the SL-EL model presented in this article is student-focused, transforming the teacher-focused approach while enhancing resource gathering and effectively improving the teaching pace. The research concludes that the SL-EL system enhances students' learning effectiveness based on feedback from learners and instructors.

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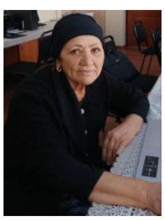

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