Development of an Online Attendance Register System (OARS) using barcode technology: Going green in class


Mncedisi Trinity Dewa
University of the Witwatersrand


Lungile Nyanga
North-West University

DEVELOPMENT OF AN ONLINE ATTENDANCE REGISTER SYSTEM (OARS) USING BARCODE TECHNOLOGY: GOING GREEN IN CLASS

M.T. Dewa[1*] and L. Nyanga[2]
[1]School of Mechanical, Aeronautical and Industrial Engineering
University of the Witwatersrand, South Africa
mncedisi.dewa@wits.ac.za

[2]Department of Industrial and Systems Engineering
Cape Peninsula University of Technology, South Africa
nyangal@cput.ac.za

ABSTRACT

Keeping track of student attendance in class is a key aspect in universities when monitoring potential at risk students. In most cases, tertiary institutions use paper-based registers which students sign to indicate attendance. This approach has a majority of shortcomings which include forgery of signatures on behalf of non-attending students, failure to identify struggling students and the land pollution threat posed by disposed paper. This paper focuses on the digitisation of classroom roll-call operations in a South African institution of higher learning through the development of a digital assistance system known as an Online Attendance Registry System (OARS). A morphological analysis is employed to describe the system's functionality while barcode technology was employed for the auto identification of students. The developed OARS was deployed to, and validated by three lecturers for a number of courses with improved attendance record-keeping and tracing. Results of the deployed system show an improvement in the real-time visibility of class demographics through customised dashboards.

Key words: Class attendance register, digital assistance

[*] Corresponding Author

1 INTRODUCTION

The importance of class attendance within the Higher and tertiary education sector cannot be under-estimated. This is essentially because of the crucial role contact classes play in ensuring knowledge acquisition in a conducive environment [1]. During class or lecture periods, learners are encouraged to adopt critical thinking, granted an opportunity to work collaboratively and ask questions, thus gaining a clearer understanding of the material presented. According to Sleigh and Ritzer [1], class attendance can enhance retention of information and helps students develop skills such as self-discipline and time management. Furthermore, a significant number of studies conducted in Asia [2] and Europe ([3]; [4]; and [5]) have shown a positive correlation between class attendance and student academic performance. However, the subject remains under debate as some recent studies revealed no significant correlation between class attendance and student performance ([6] and [7]). This is mainly because there are a variety of other reasons which can be attributed to poor student performance including financial constraints, poor preparation, stress, anxiety, sickness or a lack of accommodation [8].

Due its importance, the attendance register has been utilised for keeping track of student attendance during contact classes [9]. Different institutions use these records for varied purposes. In some cases, adequate class attendance serves as a prerequisite for qualifying to write assessments, while in most cases the records are only kept for accountability purposes. A number of instructors require information such as percentage attendance for purposes of making some decisions. Traditionally, manual methods of taking class attendance records which involve signing a circulated attendance sheet or paper are employed [10]. This approach carries a lot of shortcomings which are discussed in this paper.

With the recent rise of digital technologies such as Internet of Things (IoT) devices [11], digitalisation of class room attendance operations is an achievable reality [12]. In the paper, the development and deployment of a Digital Assistance System (DAS) which employs barcode technology known as an Online Attendance Register (OARS) is presented. In Section 2, the shortcomings of manual attendance systems is briefly discussed from the literature before the rationale for using barcode technology is outlined based on recent work. The methodology adopted is presented in Section 3, with a morphological box derived for system description purposes. We then present results based on design and use of the system in Section 4. The identified challenges during deployment are used to recommend a road map for future work in Section 5.

2 LITERATURE

Though manual attendance register sheets have been employed as the traditional means of collecting attendance data, this approach has a number of shortcomings. Firstly, the method is time-consuming and cumbersome. Nowadays, a majority of classes can be huge (with over two hundred students per contact session). The bigger the class, the more time it will take for all signatures to be captured. Secondly, the manual approach is prone to human error and fraud. The risk of having students sign on behalf of their friends is a major concern as this leads to inaccurate results. In addition, one may erroneously sign their name in the wrong row (i.e. against another person's name). After collecting attendance data over a long period of time, the instructor will need a proper filing system in place for them to manage the attendance sheets, making the process difficult to maintain. In most cases, these records are kept for purposes of determining the percentage attendance per class and per student for decision making purposes [10]. However, when there are huge volumes of attendance sheets, such manual calculations can be time-consuming and lead to inaccurate results. Thirdly, paper can easily get lost, torn or worn away. The disposal of the paper leads to land pollution which can pose an environmental threat.

Furthermore, with the recent health threat posed by the novel coronavirus (also known as Covid-19), exchange of material like paper can also present a risk of contagion (spread of the virus) [13]. The Covid-19 pandemic has seen companies include as part of their protocols avoiding the exchange of material (like paper) as the virus stays on surfaces for a certain period of time. As a result, the traditional paper-based approach can pose a serious health dilemma during these times.

Based on these shortcomings, other methods of collecting class attendance records need to be explored and employed. One approach can involve the digitising of the class attendance process. The fourth Industrial revolution (also known as Industry 4.0) has ushered the world into a new phase where manual processes can be digitised [14]. Though most efforts have focused on the digitalisation of operations in other domains like the manufacturing sector [15], digital assistance systems have also been under development for use in the education sector.

Green business practices basically involve the implementation of sustainability principles during business operations to promote environmentally friendly and sound operations. These sustainability principles are centred on four Rs which are; Reduction, Reuse, Recycling and Recovery. Studies have revealed that reduction in use of paper-based systems significantly reduces waste while protecting the environment [16]. The design presented in this paper involves the replacement of a paper-based system with a system which employs recyclable plastic barcoded cards and barcode technology (readers) thus transforming the attendance data-capture operations by making them become eco-friendly. The next section looks at the State-of-the-art with regards to digitalisation of class attendance records systems.

2.1 State of the art

The process of digitising different parts of business operations to support workers or users results in the development of Digital Assistance Systems (DAS) [16] and Technical Assistance Systems (TAS) [18]. Hinrichsen, Riediger and Unrau [19] defined an assistance system as a system (either technical or digital) which receives and processes information from its environment in order to support workers carrying out their tasks as illustrated in Figure 1. The purpose of a DAS is to bridge the gap between the information an operator has and the one required to conduct a task through detailed digital representation of information. As a result, DASs reap benefits in causing reduction of training time, search time, operating errors and improving work in stressful scenarios [20].

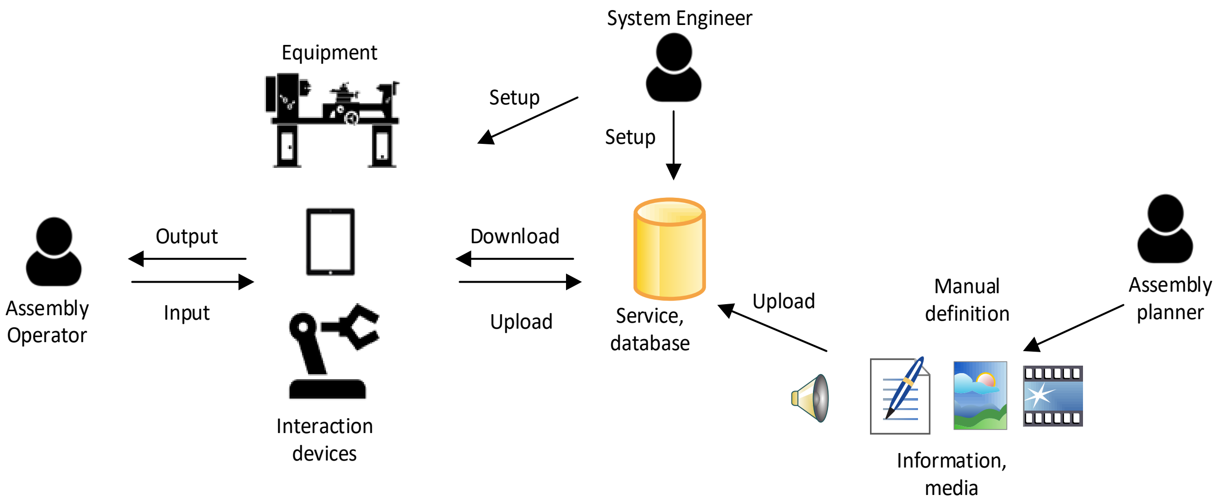

Figure 1: Schematic Structure of a Digital Assistance System (Adapted from Reisinger et al.[21])

Though DASs have been employed widely in manufacturing as discussed above, emerging work is also seen in the education sector. Different digital technologies have been used to digitise the attendance registry system. Web-based solutions for class attendance have been developed in the past few years [22]. A number of Higher and tertiary education institutions employ Learner Management Systems (LMS). These are web-based solutions and in most cases they have the functionality of capturing class attendance records. However, due to the investment cost required to obtain LMSs, this solution is not viable in some cases (where there is low capital investment for such systems). Furthermore, a sustained internet connection is required for the process of capturing learner attendance via a web-platform. In other work, a biometric approach was employed to obtain class attendance records [23]. The finger print scanning technique is the most commonly used approach via this route, with students having their fingerprints scanned through a device (fingerprint scanner) to reckon their presence for a lesson [23]. Though this method shows improved speed of data collection, the risk of contagion discussed earlier is possible if the surface on the fingerprint scanner used is not continuously cleaned. One recent breakthrough in the use of biometrics is the use of face-recognition technology to record student presence for class [24]. This approach is similar to that of scanning the iris of each pupil since every human being has unique eye characteristics. Though the biometric approaches have proven successful with regards to security and speed merits, installing such systems is usually an expensive venture which also requires clearance with regards to ethical predicaments. Mobile technology [25] and SMS [26] functionality have also been employed for purposes of recording class attendance. Though both methods require a reliable network, they have merit in that the data collection can be conducted in a distributed manner. In other studies, Near Field Communication (NFC) and Radio Frequency Identification (RFID) technologies have been employed for class attendance to speed up the process through the scanning of cards [27]. Both methods also require a huge capital investment and maintenance of a conducive environment for the readers (both RFID and NFC).In this paper, barcode technology will be employed as the auto identification technology for capturing student attendance. This method was selected due to the merits of barcode technology has as an established, widely used approach which is cheap and reliable.

3 RESEARCH METHODS AND MATERIALS

According to Oks, Fritzsche and Lehmann [28], the digitalisation of any process is a complex exercise which requires a strategic and systematic approach. Unfortunately, the current literature lacks sufficient information on generic models or methodologies for the strategic digitalisation of processes [29]. In the paper, the generic product development process [30] shown in Figure 2 is used in the development of the OARS.

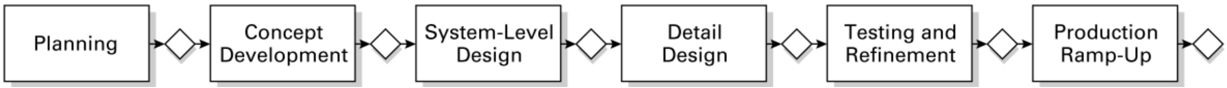

Figure 2: Generic product development process [30]

3.1 Concept generation

To identify the customer needs, a focus group interview with the selected system users was conducted to derive the requirements. A total of five lecturers congregated and were interviewed from the Engineering Faculty of a University of Technology. The focus group session followed a semi-structured format which required information on user needs when collecting attendance records. During the semi-structured focus group interview, questions regarding desired features in an automated attendance registry system were discussed. The focus group session lasted approximately sixty minutes.

Only one of the five respondents indicated that they had once used an online attendance register embedded within the LMS used by the institution. The other four, always used the manual attendance register sheets and indicated that it wouldn't be feasible to use the available online register as it depended on a consistent internet connection. Based on the discussions, the key features which stood out are:

- Ease of use;
- Ability to function without the need of a consistent internet connection;
- Ability to generate an attendance register in PDF format;
- Ability to compute percentage attendance per class;
- And ability to compute the percentage attendance per student so as to determine the at risk students.

According to all the focus group participants, the required calculations would enable swift response in monitoring both class and student behaviour. Though a digital solution was recommended as an improvement to the manual approach, all five respondents indicated the need for the digital attendance sheets to be stored for future reference, hence the need for PDF file generation and backup of the registers.

The House of Quality was used to turn the customer requirements into the system needs. Five concepts were developed and the concept selection methodology proposed by Ulrich and Eppinger [30] to select the final concept was employed. The methodology consists of the processes of concept screening and scoring. The concept scoring phase involved preparation of selection matrix, rating of concepts, ranking of concepts, combining and improving the selected concepts and reflection on the results.

3.2 System Level Design

A systems engineering approach which follows the user-centric model [11] was selected as the most suitable approach in the development of the system during the system level design. The Vee model [31] was utilised to decompose the system and determine the system requirements. At a high level design, UML modelling was used. Thereafter a morphology box was used in the component detailed design while Google sheets and AppSheet were used in the implementation of the software. The system was verified and validated by lecturers in the engineering faculty.

3.2.1 Requirement analysis

Functional requirements of the system were developed from the customer requirements determined in the concept development stage. The basic functional requirements of the system are that the system should be able to enrol/register a student and lecturer, update the student and lecturer information while managing and updating attendance records.

3.2.2 UML Modelling

The basic Use case diagram which outlines the system's primary functionality is shown in Figure 3. A conceptual model for the system was developed using the MS Visio software. The basic functions of the system include lecturer and student enrolment, lesson planning and definition and attendance register capturing. An Entity Relationship Diagram (ERD) shown in Figure 4 was developed to represent the class diagram for the system. One-to-many relationships between the different parts of the system were established. In some cases, the principle of abstraction was employed to simplify the design for instance in reality a many-to-many relationship exists between the topics and lessons entities. However, the system adopted a one topic to many lessons relationship.

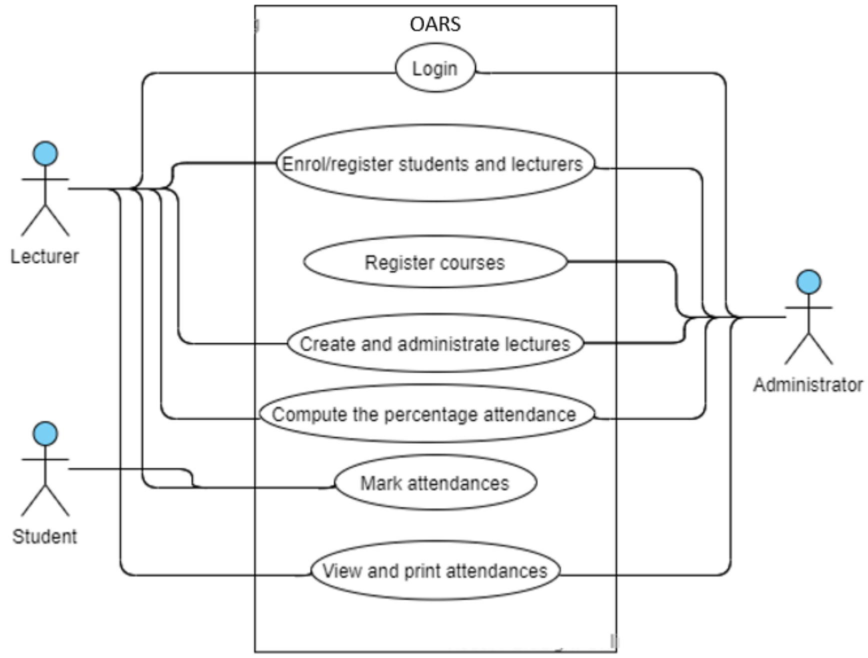

Figure 3: OARS Use Case diagram

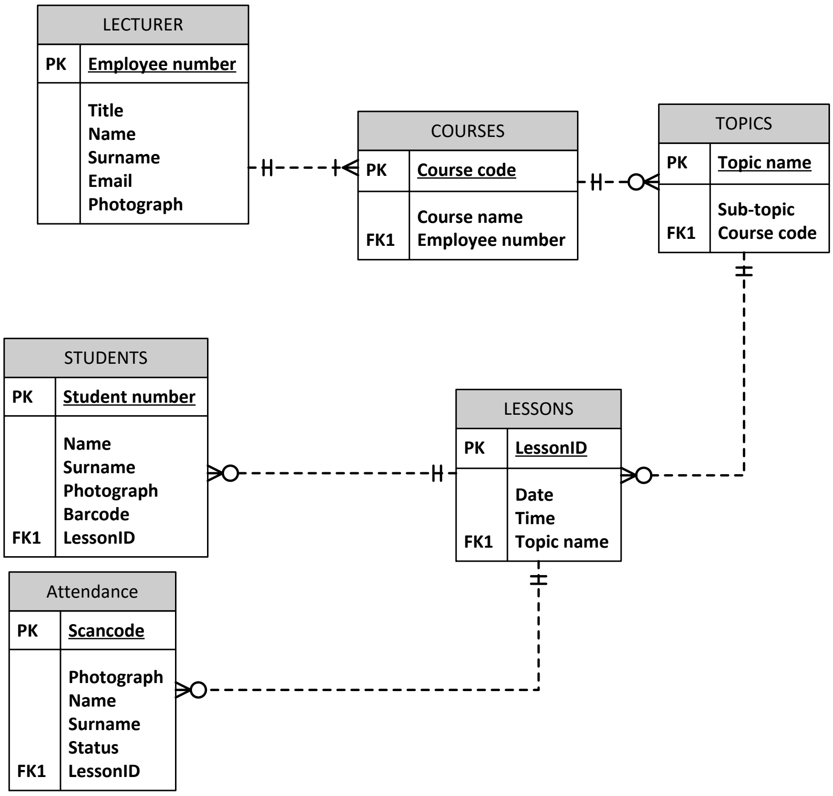

Figure 4: Entity Relationship Diagram for OARS

3.3 Detailed design and system implementation

The AppSheet platform was utilised to develop a mobile web-based solution [15]. A morphology box was utilised to describe the system functionality. Mobile technology was used due to its ability to scan barcodes as well. As a result, there would be no need to invest in stand-alone barcode scanners as each instructor will be able to scan cards using their own mobile phone. The third stage involved system testing and deployment. During this phase the developed system was tested in a real classroom environment and the results obtained.

3.3.1 System characteristics

The characteristics of a developed DAS can be described using a morphology box. The purpose of the morphology method is to present a solution description by breaking down a complex situation into individual characteristic values. Through a morphology, the characteristic values of a specific DAS can be described relating the individual features of the characteristics. Hinrichsen, Riedieger and Unrau [32] developed a morphological box for describing the features of a developed assistance system. This box (presented in Table 1) will be adapted and used during the system description in section 3.3.2.

Table 1: Morphological analysis of a designed Digital Assistance Systems [32]

CHARACTERISTICS	CHARACTERISTIC VALUES						
TYPE OF SYSTEM SUPPORT	Physical				Informational		
TYPE OF DIGITAL ASSISTANCE SYSTEMS	Stationery (fixed installation)	Mobile (mobile installation)			Hand device	Wearable -Head -Upper body -Arms/Hands -Legs/Feet	
DATA TRANSFER	Wired				Wireless		
TYPE OF SUPPORTED OPERATIONS	Joining	Handling		Adjusting	Controlling	Auxiliary processes	Setting up the Assembly system
SCOPE OF PROCESS SUPPORT	Partial process(es)				Total process		
HUMAN-MACHINE INTERFACE	Unimodal				Multimodal		
TYPE OF INFORMATION OUTPUT	Visual (optical)			Auditory (acoustic)		Tactile-kinesthetic (tactile)	
TYPE OF VISUAL INFORMATION OUTPUT	On-screen display			Representation in the working area		Working area display superimposed over the assembly object	
SCOPE OF VISUAL INFORMATION OUTPUT IN THE WORKING AREA	No output	Selective presentation		Limited display of symbols, images and drawings		Extensive presentation of items such as images, videos and animations	
TYPE OF THE INFORMATION INPUT/SYSTEM CONTROL	Manual (via actuators)	Verbal (voice control)			Gesturing (tracking system)	Automatic (sensory)	
SCOPE OF USER CONFIGURATION	Set configuration of information input and output			Individual configuration of information output		Individual configuration of information input and output	
USER RECOGNITION	None			Registration and uploading of user profiles		Automatic registration and uploading of user profiles	
SITUATION/MOTION DETECTION	None		Via measurement sensors		Via optical sensors	Other	
COMPATIBILITY/INSTALLATION EFFORT	Entire workplace has to be newly configured		Basic adjustments made to the workplace		Minor adjustments made to the workplace	No adjustments made to the workplace	
FLEXIBILITY IN RECONFIGURING THE WORKPLACE	Substantial adjustments to be made to the main hardware		High software reconfiguration effort (done by qualified specialists)		Average software reconfiguration effort (done by specialists on site)	Low software reconfiguration effort (done by user on site)	

Assistance systems can be classified in terms of the purpose they serve [33]. These application areas can include manual, maintenance, inspection, costing or logistics operations (especially in the context of production). Physical assistance involves the use of robotic systems to assist in tasks which can be complex or strenuous on workers [34] while informational assistance involves availing task related data to workers so as to support decision making and reduce task-related errors [35]. Furthermore, the type of system supported determines the assistance system installation requirements. The assistance system can either be stationery, mobile, hand-held or use wearables [36]. This will eventually influence the data transfer medium used in the system, which can either we wired in a localised environment or wireless in a distributed setting [37]. The tasks supported by the assistance system can also be employed as a classification criteria. Hinrichsen et al. [32] only used assembly operations in the description and went on to distinguish support of all or some of the operations. However in some contexts, the tasks may differ depending on the area in which the assistance is required. Depending on the type of system (application area) being supported, physical or informational assistance may be required.

Furthermore, the interaction requirements of system users can also be employed in distinguishing assistance systems. The type of user interface [38], recorded input data [39] and displayed information output [40] define the interaction characteristics of an assistance system. Similarly, the system users also contribute the system characteristics in terms of the need for configuration and recognition by operators while using the system [32]. Finally, some assistance systems may require the recording of environmental information. As a result, situational and motion detection by sensors may be needed. In such cases the need to reconfigure the workplace facility or not needs to be evaluated while monitoring the compatibility of the assistance devices with the systems already existing in the business ecosystem [32].

3.3.2 System description and architecture

To facilitate distributed collection of class attendance records, mobile technology was selected and employed for the edge devices. A majority of mobile devices carry a number of important sensors embedded in them which capture textual, video, image or audio data. Some smart mobile devices also have advanced sensors like gyroscopes, accelerometers, fingerprint sensors and barcode scanning capabilities [41]. Likewise, the AppSheet platform allows for capture of barcode data. As a result, a low investment will be required to deploy and run the system as each instructor will be able to scan student and staff cards using their own smart devices, eliminating the need to purchase and install stand-alone barcode scanners. Figure 5 below illustrates the system architecture of the OARS. The system facilitates enrolling of student and lecturer information. Thereafter, the primary users (lecturers) can define their courses. In addition on a daily basis, lecturers can load their lesson details and collect attendance information during the class using their mobile devices.

All captured information is stored in the backend Google sheets database. Upon saving a record, a pdf file of the attendance register is generated and emailed to the Lecturer’s email address.

The system properties were described using an adapted version of the morphological box presented in Table 1. The morphological box for the system is presented in Table 2 below. The developed system is an informational system which utilises hand-held mobile devices for data collection. The scope of operations supported include enrolment of users (students and lecturers), course definition, lesson planning and attendance register recording via scanning barcodes of student cards. The users can see information displayed via their user interfaces. The system can work with wireless internet connectivity. All the information in the system is manually collected. The types of data captured include textual data (like names), date or time data (day and time of class), images (photos of students and lecturers), barcodes and files (lesson guides). However, barcodes can be scanned while the system is not connected to the internet, with the backend database only updated once a connection is established. Due to the distributed nature of the data collection, the system will not require any changes to the workplace layout.

Table 2: Morphological box for the developed OARS

CHARACTERISTICS	CHARACTERISTIC VALUES					
TYPE OF SYSTEM SUPPORT	Physical		~~Informational~~			
TYPE OF DIGITAL ASSISTANCE SYSTEMS	Stationery (fixed installation)	Mobile (mobile installation)	~~Hand device~~	Wearable		
DATA TRANSFER	Wired		~~Wireless~~			
TYPE OF SUPPORTED OPERATIONS	~~Staff enrolment~~	~~Student enrolment~~	~~Course definition~~	~~Lesson planning~~	~~Scan student cards~~	~~Generate PDF register and results~~
SCOPE OF PROCESS SUPPORT	Partial process(es)		~~Total process~~			
HUMAN-MACHINE INTERFACE	Unimodal		~~Multimodal~~			
TYPE OF INFORMATION OUTPUT	~~Visual (optical)~~	Auditory (acoustic)	Tactile-kinesthetic (tactile)			
TYPE OF VISUAL INFORMATION OUTPUT	~~On-screen display~~	Representation in the working area	Working area display superimposed over the assembly object			
SCOPE OF VISUAL INFORMATION OUTPUT IN THE WORKING AREA	No output	~~Selective presentation~~	Limited display of symbols, images and drawings	Extensive presentation of items such as images, videos and animations		
TYPE OF THE INFORMATION INPUT/SYSTEM CONTROL	~~Manual (via actuators)~~	Verbal (voice control)	Gesturing (tracking system)	Automatic (sensory)		
SCOPE OF USER CONFIGURATION	Set configuration of information input and output	Individual configuration of information output	~~Individual configuration of information input and output~~			
USER RECOGNITION	None	~~Registration and uploading of user profiles~~	Automatic registration and uploading of user profiles			
SITUATION/MOTION DETECTION	None	Via measurement sensors	Via optical sensors	~~Other: Barcode scanning~~		
COMPATIBILITY/INSTALLATION EFFORT	Entire workplace has to be newly configured	Basic adjustments made to the workplace	Minor adjustments made to the workplace	~~No adjustments made to the workplace~~		
FLEXIBILITY IN RECONFIGURING THE WORKPLACE	Substantial adjustments to be made to the main hardware	High software reconfiguration effort (done by qualified specialists)	Average software reconfiguration effort (done by specialists on site)	~~Low software reconfiguration effort (done by user on site)~~		

Three Lecturers agreed to test the system for their courses (nine different courses in total). The results from the testing phase are discussed in the section 4. The OARS system consists of three main modules for enrolment of students, lecturers and lesson planning as shown in the system architecture in Figure 5.

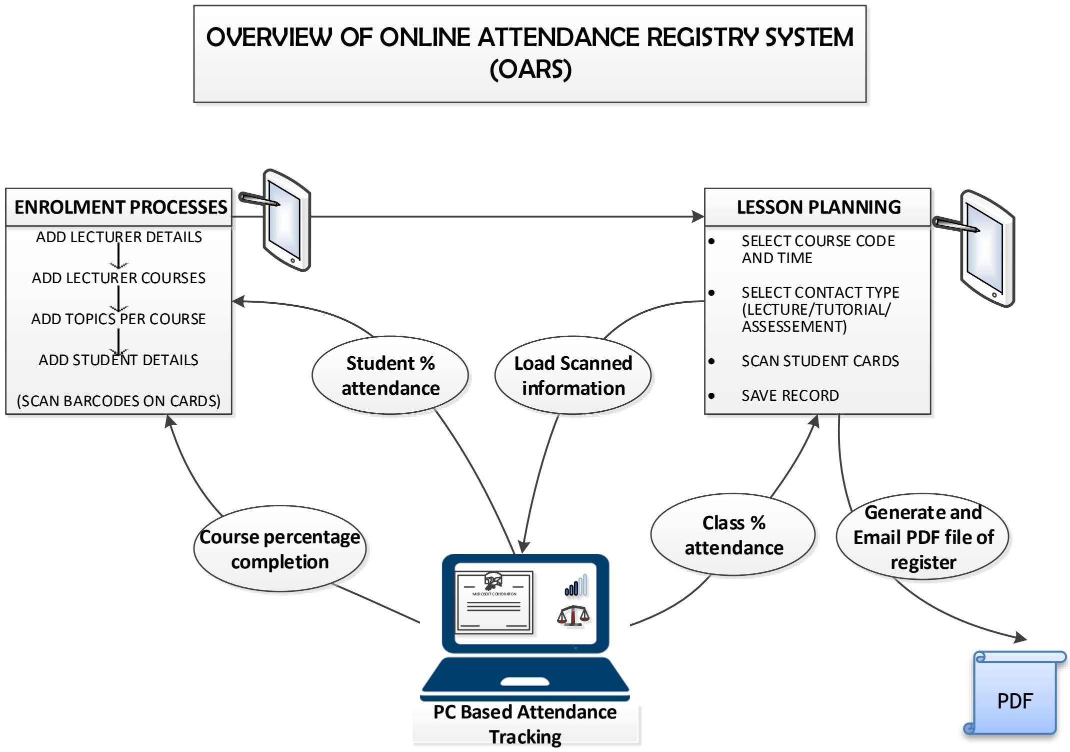

Figure 5: System architecture OARS

4 RESULTS

4.1 System testing, deployment and dashboards

The system was validated through testing it during an entire academic year (two semesters) of study. Three lecturers and a total of 131 students participated during this phase. The administrator of the system deployed the system to the lecturers via their email addresses for them to install on their mobile smart devices. Both lecturer and student cards have barcodes of type Code 39. The AppSheet platform can read a wide variety of barcodes. The scan time per barcode was approximately less than a second with the read distance been one meter. The main shortcoming of employing barcode technology is that the quality of the barcode embedded on the card can affect the read time. As a result in some instances the read time took slightly longer depending with the barcode clarity or resolution. Another drawback experienced was that the application could only read one barcode at a time.

4.2 Analysis of the results

The system was developed with simple user interfaces. Three main input interfaces for staff enrolment, student enrolment and lesson planning were developed (see Figure 6**).** In the paper, only user interfaces which do not reveal student, lecturer or institution information are shown. Before a contact session, the lecturer defines the nature of the class by inputting the course, topic covered, lesson time and nature of class (e.g. lecture, tutorial or assessment etc.). For a defined lesson, the barcode on student cards is scanned to denote their presence for a class. During the scanning, the system automatically records the details of each student in attendance and computes the total number of students attending class. This information is displayed in report format and converted into a pdf document which is automatically sent via email to the Lecturer. A major shortcoming of the method was that at times students would not bring their cards to class. To overcome this shortcoming, students were encouraged to take photos of their student cards using their smart phones. That way, the barcode would still be scanned from the phone.

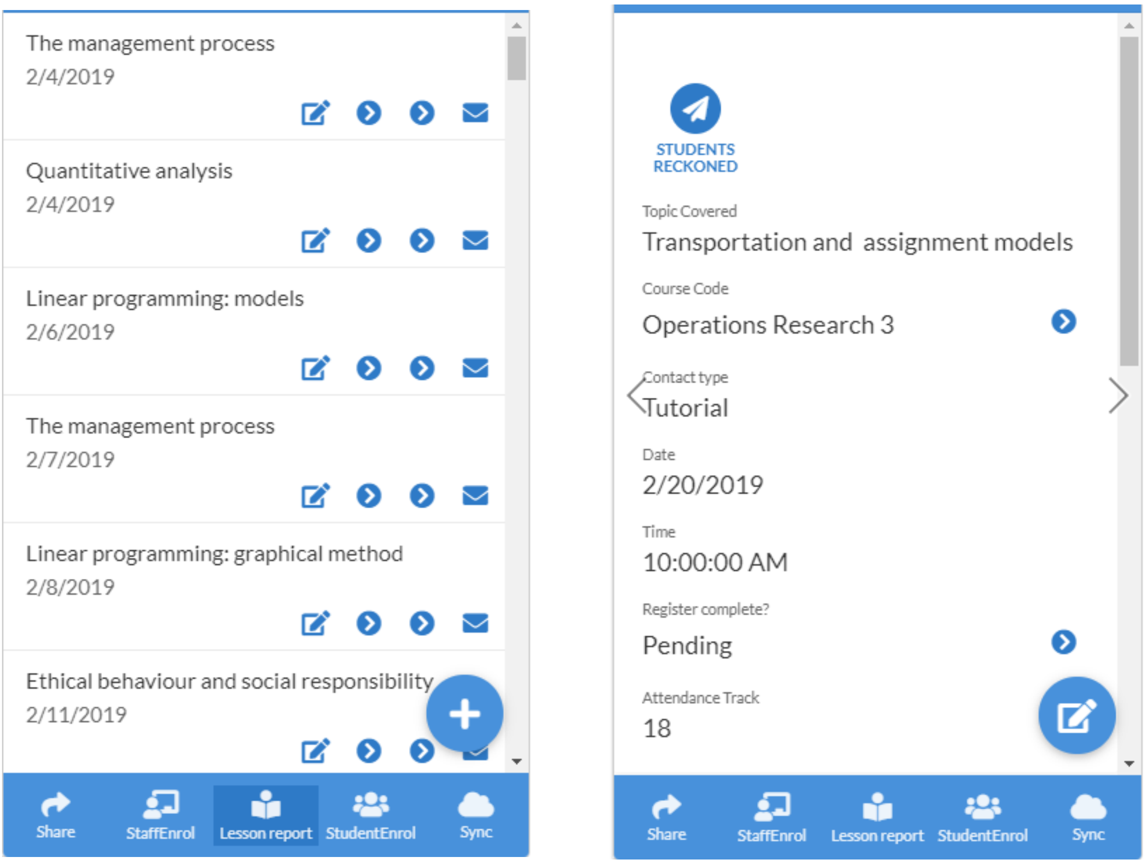

Figure 6: Screen shots of OARS (Lessons - (left) and attendance record - (right) interfaces)

The system was programmed to display two crucial dashboards: percentage class attendance per semester and individual student attendance. These dashboards were included as a result of the requests placed by the lecturers during the focus group interviews. The percentage class attendance dashboard is presented in Figure 7 below.

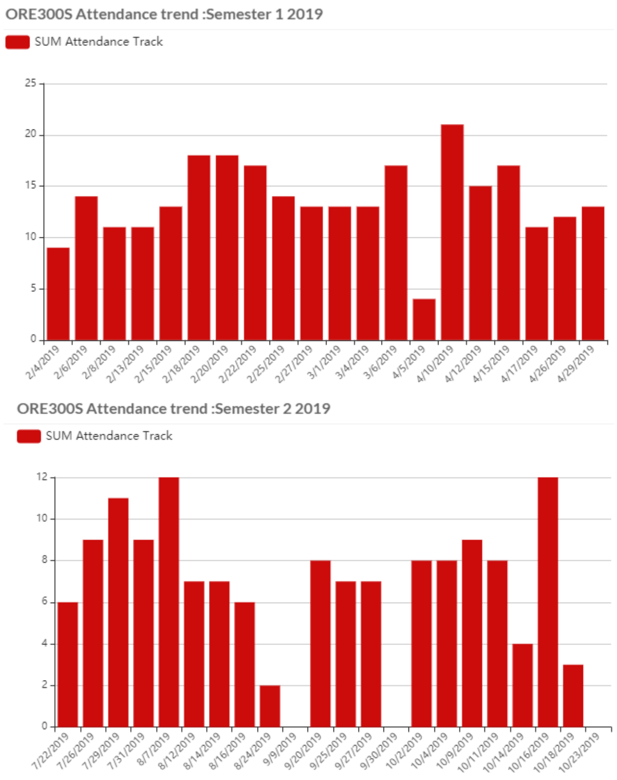

Figure 7: Course attendance trend dashboard (Semester 1 and 2)

Eventually, the use of the system eliminated the need for a paper-based attendance sheet while improving the efficiency and efficacy of attendance record keeping. This boosted the interaction between the lecturers and students concerning matters related to class attendance. In some instances, lecturers would communicate attendance trends with students in a way to find out reasons for non-attendance and encourage it.

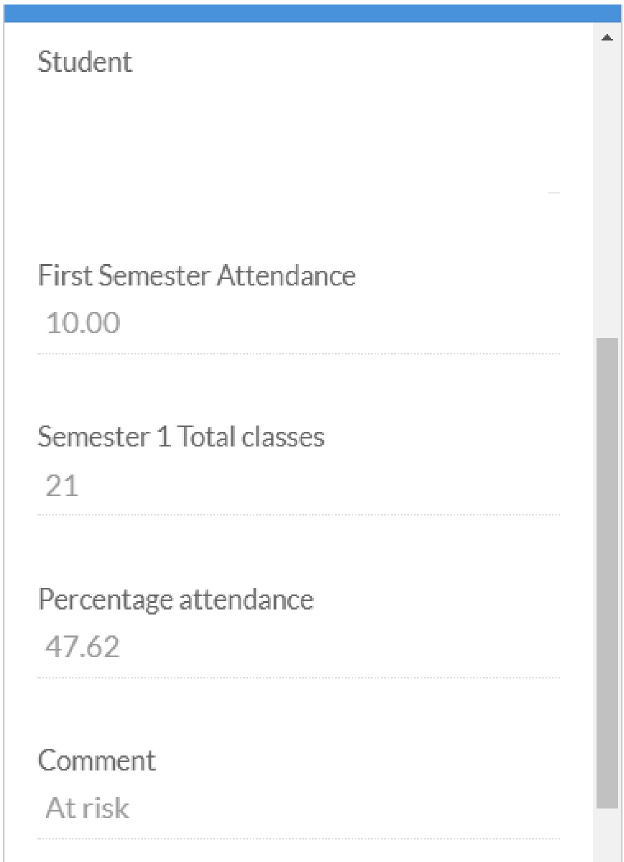

Figure 8: Example of student attendance record

Another key dashboard embedded in the system is the ability to track individual student attendance trends within a specified period of time as illustrated in **Figure 8** above. Upon selecting a student from the database of enrolled students, and selecting the course and period details, the total number of classes the student will have attended are displayed. The percentage attendance is then computed with a comment of either good attendance or poor attendance (at risk) shown.

5 CONCLUSION

The developed Online Attendance Registry System (OARS) significantly improved the speed of attendance registry data collection. Eliminating the use of paper is a significant step in ensuring green practices are adopted in the classroom environment. This results in immense benefits as records kept in digital format are easy to access, manipulate and analyse. More dashboards for tracking of different parameters associated with class attendance can still be developed and extended within the system to facilitate a richer analysis and ensure real-time alerts. An example of such an extension is the inclusion of real-time alerts or communication to students showing trends of poor attendance. Using event-driven platforms like Zapier [42], triggered alerts to students not attending classes can be generated and sent via email or SMS to encourage participation. Furthermore, future work can be conducted on integrating barcode readers which conduct bulk reading of students' cards to speed up the process. One of the main benefits of digitising the class attendance registration process is the ability to obtain crucial information regarding classes in real-time, eliminating the need to keep huge files of attendance sheets, hence going green.

6 REFERENCES

[1] **Sleigh, M. J., and Ritzer, D. R.** 2001. Encouraging student attendance. *APS Observer*, 14(9): 19–20, pp 32–33.

[2] **Chen, J. and Lin, T.** 2008. Class Attendance and Exam Performance: A Randomized Experiment. *Journal of Economic Education*. 39(3):pp. 213-227.

[3] **Massingham, P., & Herrington, T.** 2006. Does attendance matter? An examination of participant attitudes, participation, performance and attendance, *Journal of University Teaching & Learning Practice*. 3(2).

[4] **Paisley, C. and Paisley, N. J.** 2004. Student attendance in an accounting module-reasons for non-attendance and the effect on academic performance at a Scottish University. *An International Journal of Accounting Education*. 13(1), pp. 39-53.

[5] **Kirby, A. and McElroy, B.**, 2003. The Effect of Attendance on Grade for First Year Economics Students in University College Cork," The Economic and Social Review. *Economic and Social Studies*,34(3): pp. 311-326.

[6] **Eisen, Schupp, Isserof, Ibrahimi, Ledo, and Armstrong,** 2015. Does class attendance matter? Results from a second-year medical school dermatology cohort study.2015 Jul;54(7):pp. 807-816. doi: 10.1111/ijd.12816.

[7] **Hidayat, L., Vansal, S., Kim, E., Sullivan, M., and Salbu, R.** 2012. Pharmacy Student Absenteeism and Academic Performance. *American journal of pharmaceutical education*. 76(1):pp. 8.

[8] **Newman-Ford, L.E., Fitzgibbon, K., Llyod, S. & Thomas, S.L.** 2008. A Large-Scale Investigation into the Relationship between Attendance and Attainment: A Study Using an Innovative, Electronic Attendance Monitoring System, *Studies in Higher Education*, 33(6), pp. 699-717.

[9] **Alexander, V. and Hicks, R.** 2016. Does Class Attendance Predict Academic Performance in First Year Psychology Tutorials?, *International Journal of Psychological Studies*. 8:pp. 28–32.

[10] **Tabassam Nawaz, Saim Pervaiz, Arash Korrani and AzharUd-Din,** 2009. Development of Academic Attendance Monitoring System using fingerprint identification", *International Journal of Computer Science and Network Security*, 9 (5), pp. 164-168.

[11] **Dewa, M.T., van der Merwe, A.F., and Matope, S.**. 2018. A decision-making framework for implementing digitalisation in the South African tooling industry. *South African Journal of Industrial Engineering*, *29*(4), 245-262.

Available: https://dx.doi.org/10.7166/29-4-1903

[12] **Shrivastava, K., Manda, S., Chavan, P.S., Patil, T.B., and Sawant-Patil, S.T.** 2018. Conceptual Model for Proficient Automated Attendance System based on Face Recognition and Gender Classification using Haar-Cascade, LBPH Algorithm along with LDA Model, *International Journal of Applied Engineering Research*, 13(10):pp. 8075-8080.

[13] **Singhal, T.** 2020. A Review of Coronavirus Disease-2019 (COVID-19). *Indian J Pediatr* **87**, pp. 281–286.

Available: https://doi.org/10.1007/s12098-020-03263-6

[14] **Dewa, M. T., Adams, D. Q., Tendayi, T. G., Nyanga, L., Gxamza, M. and Ganduri, L.** 2019. Industry 4.0: A Myth or a Reality in South Africa? *Proceedings*

of the 29th South African Institute for Industrial Engineering (SAIIE), pp. 649 – 666.

[15] **Dewa, M., van der Merwe, A.F. and Matope, S.** 2018. Digitalisation of shop-floor operations in the South African tool, die and mould-making industry. *South African Journal of Industrial Engineering*, 29(2), pp. 153–170.

Available: https://doi.org/10.7166/29-2-1899

[16] **Ahmad, M.** 2016. Green business practices: Balancing environment and economic desires. *International Journal of Multidisciplinary Research and Development*, 3(5): pp. 266-268.

[17] **Hold, P. and Sihn, W.** 2016. Towards a Model to identify the Need and the Economic Efficiency of Digital Assistance Systems in Cyber-Physical Assembly Systems, *In International workshop on Cyberphysical Production Systems at CPS Week 2016*, Vienna, Austria, IEEE.

[18] **Krüger, J., Lien, T.K., and Verl, A.** 2009. Cooperation of human and machines in assembly lines," in *CIRP Annals 2009*, pp. 628–646.

[19] **Hinrichsen, S., Riedieger, D. and Unrau, A.** 2016. Assistance Systems in Manual Assembly. *Proceedings of 6th International conference on Production Engineering and Management*, 29 September 2016, Villmer Lemgo, Germany, pp. 3-14.

[20] **Zaeh, M.F., Wiesbeck, M., Engstler, F., Friesdorf, F., Schubo, A., Stork, S., Bannat, A., Wallhoff, F.** 200. Cognitive Work Systems in the Assembly. Adaptive assembly guidance using condition-based, environment-dependent statement generation. *In: ZWF – Journal for economical factory operation*. pp. 644-650.

[21] **Reisinger, G., Komenda, T., Hold, P., and Sihn, W.** 2018. A Concept towards Automated Data-Driven Reconfiguration of Digital Assistance Systems, *Procedia Manufacturing, Volume 23,* pp. 99-104, ISSN 2351-9789.
Available: https://doi.org/10.1016/j.promfg.2018.03.168.

[22] **Othman, M., Siti Nurbaya Ismail, S.N. and Raus, M.I.M,** 2009. The development of the web-based Attendance Register System (ARS) for higher academic institution: From feasibility study to the design phase. *International Journal of Computer Science and Network Security*, 9(10),pp. 203-208.

[23] **O. Shoewu, O. and Idowu, O.A**. 2012. Development of attendance management system using biometrics, *The Pacific Journal of Science and Technology*, 13(1):pp. 300-307.

[24] **Isinkaye, F.O., Soyemi, J. and Arowosegbe, O.I.** 2020. An Android-based Face Recognition System for Class Attendance and Malpractice Control. *International Journal of Computer Science and Information Security (IJCSIS)*, 18(1), pp. 78-83.

[25] **Kambole M. B. and Phiri N.** 2018. Mobile Attendance Class Register (MACR): The Effective Way to Take Class Attendance in Urban Schools of Zambia. *The International Journal of Multi-Disciplinary Research*, pp. 1-10.

[26] **Immanuel, A. and Tulasi, B.** 2010. Attendance Registering System (ARS) in Academic Institutions using SMS, *Emerging Trends in Information Technology (EIT)*, pp.

[27] **Mohandes, M.A.** 2017. Class attendance management system using NFC mobile devices, *Intelligent Automation & Soft Computing*, 23(2):pp. 251-259.

[28] **Oks, S.J., Fritzche, A. and Lehmann, C.** 2016. The digitalisation of industry from a strategic perspective. Proceedings of R and D Management Conference

2016 "*From Science to Society: Innovation and Value Creation*", 3-6 July, Cambridge, United Kingdom, pp 1-9.

[29] **Monostori, L.** 2014. Cyber-Physical Production Systems: Roots, Expectations and Research and Development Challenges, *Procedia CIRP*, 17, pp 9 – 13.

[30] **Ulrich, K.T. and Eppinger, S.D.** 2012, *Product Design And Development*, Fifth Edition, McGraw-Hill, New York.

[31] **INCOSE**, 2011, *Systems Engineering Handbook A Guide For System Life Cycle Processes And Activities*, SE Handbook Working Group International Council on Systems Engineering (INCOSE), INCOSE-TP-2003-002-03.2.2

[32] **Hinrichsen, S., Riedieger, D. and Unrau, A.** 2016. Assistance Systems in Manual Assembly. Proceedings of 6th International conference on Production Engineering and Management, 29 September 2016, Villmer Lemgo, Germany, pp. 3-14.

[33] **Lusic, M., Fischer, C., Bonig, J., Hornfeck, R. and Franke, J.** 2016. Worker information systems: state of the art and guideline for selection under consideration of company specific boundary conditions. *Proceedings of 48th CIRP conference on Manufacturing Systems, Procedia CIRP 41,* pp. 1113 – 1118.

[34] **Müller, R., Vette, M., Mailahn, O., Ginschel, A., Ball, J.** 2014. Innovative Production Assistance for Assembly - Intelligent Worker Assistance in the assembly of large components in aviation. *In: wt workshop technology online 104 H.9. Dusseldorf: Springer-VDI 2014.* pp. 552 - 560.

[35] **Rainer R.K. and Cegielski C.G.,** (2011), Introduction to information systems. John Wiley & Sons.

[36] **Schenk, M., Mecke, R., Grubert, J., Berndt, D. and Sauer, S.** 2010. Augmented Reality: A new approach to assistance systems in production. *Industry Management* 2010; 26/2: pp. 33-36.

[37] **Fischer C, Lusic M, Bönig J, Hornfeck R. and Franke J.** (2014). Web-based Worker information systems: Data preparation and representation for the workforce leadership *in Global Cross Enterprise Engineering. Within Workshop Technology online 2014*; 104/9: pp. 581-585.

[38] **Geiser, G.** 1997. Information technology work design. In: Luczak, H., Volpert, W. (ed.): *Handbuch Arbeitswissenschaft. Stuttgart: Schäffer-Poeschel*, pp. 589 – 594.

[39] **Reinhart, G., Berlak J., Weber, V., Spangler, T., Ermisch, A., Stawinoga, C.**2001. Multimedia information in small series assembly: Conception a Realization of a multimedia worker information system. Wt Workshop technology online 2001; 91/12: p. 780-784.

[40] **Gustafsson B.** 2000. Visual Process Instructions for "knowing how". *In: Manufacturing Technology in the Information Age, CIRP International Seminar on Manufacturing Systems*, 35; 2002. pp. 147– 154.

[41] **Park, J.** 2015. Evaluating a Mobile Data-Collection System for Production Information in SMEs. *Computers in Industry*, 68, pp. 53–64.

[42] **Rahmati, A., Fernandes, E., Jung, J., & Prakash, A.** (2017, 9). IFTTT vs.Zapier: A comparative study of trigger-action programming frameworks.arXiv preprint arXiv:1709.02788. Retrieved from http://arxiv.org/abs/1709.02788.