



Design and Implementation of an Automated Certificate Generation System for Higher Education Institutions

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Abstract

Certificate generation systems play an important role in higher education institutions because they prepare certified students for the job market and induce organizational efficiency. In this context, the College of Education for Pure Science / Ibn Al-Haitham (CEPSIH) does not, however, have its own electronic system. This point motivates us to conduct this monitoring situation as a case. We designed and implemented the Ibn al-Haitham Certificate System (IHCS) as an automated certificate generation database system at the CEPSIH. This case study aims to put this system in a real educational environment into a valuable context, where the successfully implemented system meets the objectives of CEPSIH, illustrates the major bottlenecks, the overwhelming challenges, and the negative impact resulting from a time-consuming, manual certificate issue process at the CEPSIH. The authorized staff members will generate certificates using IHCS database server with a user-friendly interface. Users (or the student gradulators) will go through online panel and register before logging into the IHCS. Registered users authenticate themselves, after which new user accounts can be used to request the graduation certificate from IHCS database and then generated it automatically. To implement the IHCS, it was necessary to collect data from paper records and old Excel sheets which belong to more than 35000 graduates since 1980s. The collected data should be converted to CSV files which we designed in particular form in order to be imported to the IHCS database. Data verification and validation are conducted in specific manners within IHCS to ensure that all stored data are correct without any errors and meet certain standards of the CEPSIH. All graduate information stored in the IHCS database are encrypted by AIS algorithm using encryption key of 256 bit.

Keywords: Certificate generation; Graduate database; Data verification; Data validation; Generate e-certificate; Encrypted relational database

1. Introduction

As educational institutions have grown more and more complex, various educational matters are coming up. As administrative work is very complicated in educational institutions, it involves a number of activities that are required to be done with the highest amount of efficiency and accuracy [1,2,3]. We cannot overemphasize the software that has been developed in this aspect, with most educational institutions opting for an automated computerized system [4,5,6,7].

College of Education for Pure Science / Ibn al-Haitham (CEPSIH) in the University of Baghdad [8] is one of many collage that was depending on manual inconvenient paper system to generate the certificate of graduation. The paper system was depending on time-consuming tasks such as graduates coming to the student registry office, filling out different forms such as the application form, temporary certificate form, and permanent certificate form.

It consumes the students' time and money. The management staff (or certificate authority) have to face various problems such as assigning the students' paper sheets to create the certificates, issues in the MS word forms, which consume certificate authority time. To avoid these problems, we are introducing the Ibn al-Haitham Certificate System (IHCS) as an advanced manageable certificate generation system. The IHCS presents the graduation information in an easy and accurate way. The challenges that occurred during the implementation of the IHCS system, including: 1) the collect of data from paper records and old Excel sheets which belong to more than 35000 graduates since 1980s, 2) convert the collected data to particular designed CSV files, 3) train system concepts to the CEPSIH staff to enable them to use the IHCS.

We can summarize the main contributions of this research as follows:

- Developing an efficient approach -IHCS system- to automatically generate the certificate of CEPSIH graduates. IHCS is designed as a PHP -web based system may offer a fast access to relational databases.
- Introducing a comprehensive review of the technical difficulties faced by university staff- such as collect of data from paper records and old Excel sheets.
- Providing specific algorithm for data verification against the reliable source of paper data to ensure that all data are correct without any errors may occur during data importing.
- Providing specific algorithm for data validation to ensure that the situation of each graduate stored in the database meets certain standards of the CEPSIH.
- Encrypting all graduate information stored in IHCS database by using AES algorithm with encryption key of 256 bit.
- Applying the proposed system on a real-world case study, thus reducing the manual work and making the certificate generation process is automatically carried out in the CEPSIH.

This paper is organized as follows: Section 2 introduces an overview of related works. Section 3 presents the architecture overview of IHCS and the main methods that have been adopted in this work. Section 4 presents the summary of results and section 5 draws a conclusion and proposes future research.

2. Related Work

In the education process, it is necessary to keep the students' courses they have taken as well as the corresponding grades they achieved. When a student graduates, they might take these courses and grades in the form of a certificate for various purposes. College and university students obtain certificates for having passed the qualifying tests accomplished by the institution. Each year, the registration office in the university reproduces these certificates for the students throughout the decades. [9,10,11]

The [12] introduces a website-based application for issuing certificates in digital manner. The application can provide a facility to the event committee to issue the digital certificates for the webinar participants and then reduce paper usage. This printing system is not designed for generating the academic certificate. An automation framework to avoid the falsification of digital certificate depending on blockchain technology for verification and validation is proposed in [13]. The framework applies the cryptography using the Blockchain technology to keep the documents secure with in a shared storage system. However, this system employs the QR code to weblink of the event organizer institution for verification and validation of webinar e-Certificates.

In college of technology, Jaffna: Sri Lanka they designed the College of Technology Management System (COTMS) [14] to store the student data into a single database system. The system admin inserts the student's data and their marks into COTMS in order to automatically generate the certificate of students. The designed system is specified to the students in all department to follow up the mark data during the period of their study. In the [15] dissertation the blockchain technology and Quick Response (QR) code are used to design a certificate generation and verification system. The system provides fast and easier means of certificate verification to mitigate the level of certificates forgery. The student information that the system displays in the certificate are very limited and shorten, i.e. some important information like the total graduate average and personal graduate photo are not shown in the certificate. In Table 1, we compare between the related works to demonstrate the main contributions, technologies, advantages and disadvantages for each work.

Table 1: related works comparison

Ref	Main Contribution	Technology Used	Advantages	Disadvantages
[12]	Digital certificate issuance system for event/webinar participants	Web-based application	Reduces paper usage; simple digital generation process	Not suitable for academic certificates; lacks verification or security mechanisms
[13]	Blockchain-based system for verification of e-certificates	Blockchain, Cryptography, QR Code	High-level security; prevents falsification; shared storage for transparency	Verification limited to a web link; designed for event/webinar certificates, not academic use
[14]	College of Technology Management System (COTMS) to manage student data and automate certificate issuance	Centralized Database Management System	Automates certificate generation; supports all departments; central student data storage	Institution-specific; no advanced verification method (e.g., blockchain or QR); not scalable
[15]	Certificate generation and verification system using blockchain and QR code	Blockchain, QR Code	Quick and easy certificate verification; counters certificate forgery	Certificate lacks important student info (e.g., student photo); limited data presentation

3. Architecture overview of IHCS

In this section we present the architecture of the IHCS which meets the CEPSIH requirements. The architecture of IHCS follows some ideas presented in these approaches in order to create a manageable certificate generation system. The key idea of IHCS is to facilitate the work of CEPSIH and the request of graduates' certificates. IHCS, via its user interface, provides a) the CEPSIH certificate authority with electronic system which liberates the employers from paper records, and b) the graduates with online services that facilitate the requesting of certificate in an easy and fast way.

Figure 1 gives a high-level overview of the IHCS architecture which includes three major parts (Preparing-, Core- and Online part) with different types of elements in each part (software tools, data files, and other elements). The main three parts of IHCS architecture are distinguished with different background colors in the figure. To make IHCS works as a certificate generation system in the local server of the CEPSIH, all these architecture parts cooperate with each other in two phases: 1) in the initialization of operating environment, e.g., in the converting of the paper records into CSV files; 2) at runtime, e.g., in the management of the graduates' data, i.e., certificates editing. In the speak we provide a more detailed description and also the main features of each part of the IHCS architecture.

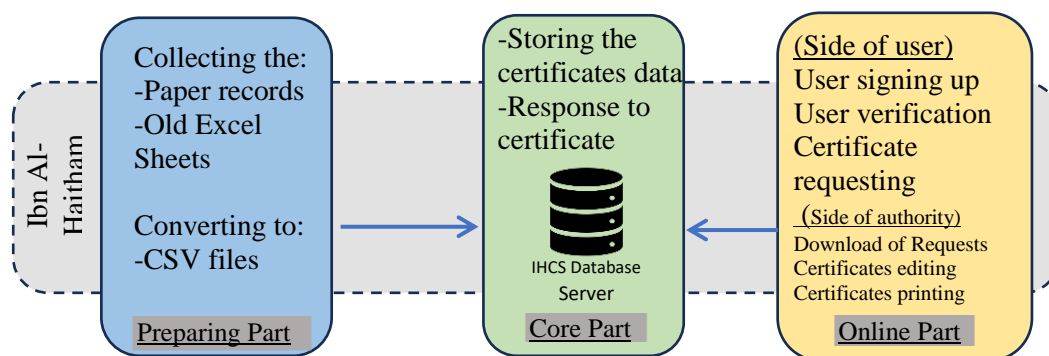


Figure 1. Architecture overview of Ibn al-Haitham Certificate System (IHCS)

3.1 Preparing the Uploaded and Stored Data

IHCS, which is presented in this paper, became the reliable system by the CEPSIH certificates authority in order to generate the graduation certifications. The information is collected about more than 35000 students that they are graduated from five departments since more than 30 years ago. All collected information will be uploaded to the local IHCS database server that can be accessed by the Intranet available in the CEPSIH. Only verified and validated information stored in the database are allowed to be used by the certificates authority to generate a specific certificate.

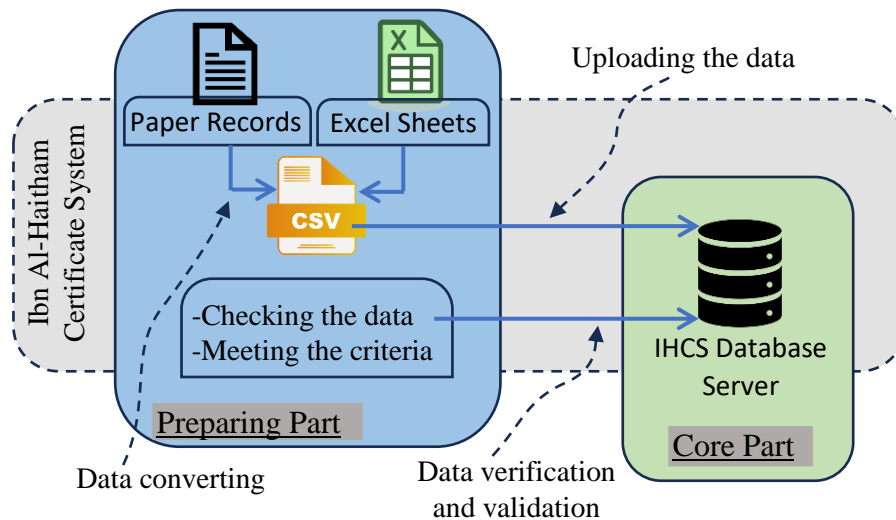


Figure 2. Environment preparing part of IHCS

Figure 2 focuses on the preparing part of IHCS architecture. This part includes different operations which work in the IHCS initialization phase. The CSV files in the figure represent the graduate information that created in the initialization phase to serve as an input for database. After the CSV files have been uploaded to the database as shown in the figure, the certificate authority should check the data and ensure that it meeting the specific criteria. We describe in the following the main three operations of the IHCS preparing part.

1. *Data Collecting and Converting*, in this operation we faced a big challenge because there was a need to collect a data from paper records and old Excel sheets. We designed a CSV file (as shown in Figure 3) and trained the employees in the CEPSIH certificate authority how to convert the data to the designed CSV file. This data conversion involved very big amount of data belong to more than 35000 graduates. The CSV files uploading is the next operation after data conversion as shown in Figure 2.

Stud No	Student Name	Mother name	Gender	Graduate Score	Graduate Round	Nationality	Date of birth	University	College	Department	Degree	Graduate Year	Study Type	Country
101	Ali Kareem	Faten	Male	83.5562	First Round	Iraqi	1996	Baghdad	CEPSIH	Physics	Bachelor	2020-2021	Moring	Iraq
102	Huda Zaki	Fatma	Female	82.2376	Second Round	Iraqi	1995	Baghdad	CEPSIH	Physics	Bachelor	2020-2021	Moring	Iraq
103	Zaid Ali	Suad	Male	79.8934	First Round	Iraqi	1996	Baghdad	CEPSIH	Physics	Bachelor	2020-2021	Moring	Iraq

Figure 3. The CSV file format of IHCS system

Figure 3 shows the format of CSV file and some values that will be imported to the relational tables of CEPSIH database. The CSV files are uploaded separately for each department and for each academic year. The IHCS refuses any CSV file that does not match against the rules of stored data inside the database e.g., data type and data sorting.

2. *Data Verification*, it is the first operation that must be carried out for each record stored in the database to give a permission to edit and print a specific certificate. The data verification employee should have a specific account in IHCS called as Data-Checker. This account gives the required authorizations to Data-Checker to

check the accuracy and completeness of stored data. This operation consists of comparing data against the reliable paper data source to ensure that all data are correct. The purpose of data verification is to correct any errors (as shown in Figure 4) that may occur during the conversion or uploading of CSV files. This operation is very necessary because inaccurate or incomplete data can generate incorrect certificate.

Not verified	Bachelor of Education	1992	Iraqi	the first	92.156000	feminine	Zeno Karim Amin	Salwa Karim Daoud Hassan	2
Audited	Bachelor of Education	1992	Iraqi	the first	90.238700	feminine	Salma Farhan	Nour Qasim Fadel Abbas	3

Figure 4. Screenshot of database records which are under verification

3. Data validation, it is the second operation that must be carried out for each record stored in the database to give a permission to edit and print a specific certificate. The data validation employee should have a specific account in IHCS called as Data-validator. This account gives the required authorizations to Data-validator to ensure that the situation of each graduate meets certain standards of the CEPSIH. The goal of data validation is to compare data against the paper archive that already available as a separated file for each graduate. Without data validation, CEPSIH may run the risk of making decisions based on incomplete data. For example, the graduate may have to pay old semester fees that didn't pay it during the study period, or may the graduate had presented incomplete documents e.g., the secondary school documents. Figure 5 illustrates some example database table records that didn't meet certain standards of the CEPSIH.

The file has been blocked	Bachelor of Science	1968	Iraqi	the first	79.8980000	feminine	Fakhria Abdul Redha	Enaam Khalaf Issa	8
The file has been blocked	Bachelor of Science	1974	Iraqi	the first	79.5270000	feminine	Beautiful Salboukh	Farha Abdul Ali Shafi	9
Approved	Bachelor of Science	1974	Iraqi	the first	77.9150000	feminine	Official falsehood	Nadia Hassan Mohammed	10

Figure 5. Screenshot of database records which are under validation

3.2 Data storing and retrieving in IHCS

According to the IHCS architecture, the core part includes the database, which stores the certificates data and then responses to the requests, that regarding to certificate generation. Figure 6 illustrates the main role of the IHCS core part, namely, to save the graduate information into the IHCS database. In Step (1), IHCS admin creates the required accounts to manage the data uploaded and saved in IHCS database. Each account, as shown in steps 2-5, has specific privileges that authorize the associated employee to do her/his work. The CSV files are uploaded to the database by the Data-Uploader in the step 2. All data stored in the database are encrypted using AES-256 algorithm as described in the next section. In the steps 3 and 4, each graduate record in the database should be verified and validated by the Data-Checker and Data-Validator; otherwise, the certificate issuer will not be able to issue and print the graduate certificate in step 5.

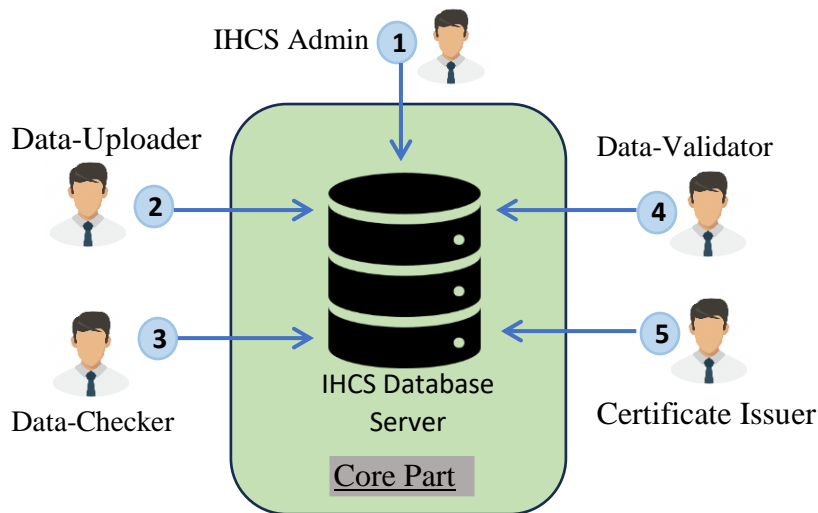


Figure 6. The core part of IHCS system

3.3 Graduation data encryption using AES-256 algorithm

IHCS implements the Advanced Encryption Standard (AES), one of the most widely used encryption algorithms to protect sensitive data in various industries, such as in healthcare [16], finance [17] and data storage [18]. AES works by using a symmetric key algorithm, where the same key is used for encryption and decryption. AES-256 is the most secure version of AES that uses a 256-bit key [19,20]. While AES-256 is the most computationally intensive, we used it in IHCS to provide maximum security for the graduate data stored in the database. The IHCS encryption algorithm, as shown in Figure 7, receives the original data as input and then produces the encrypted data to be saved in the database. The encryption key of 256 bit is used within AES algorithm to secure the graduate information. Only authorized employers can access to encrypted data stored in the database. When the Data-Checker is logged in to the IHCS, the decryption operation is carried out in order to implement the data verification. The remain authorized accounts follow the same manner when access to the encrypted data stored in the database.

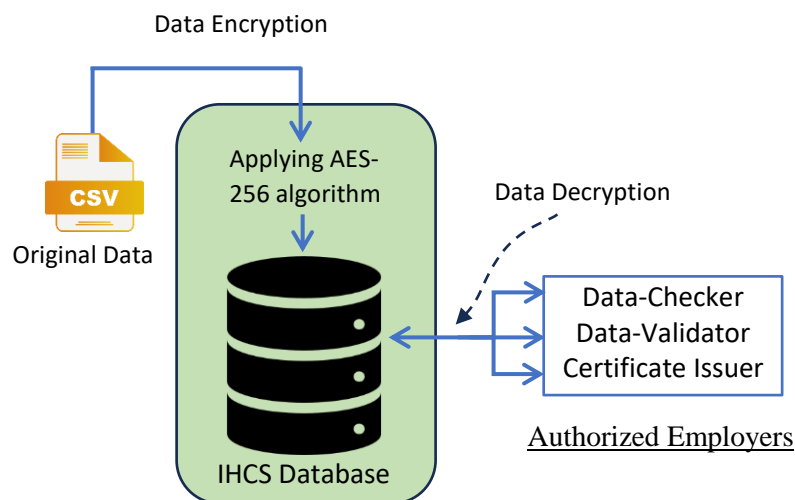


Figure 7: Using AES-256 algorithm in IHCS

3.4 Certificate Requesting and Generation

After the graduate information are uploaded to the IHCS database and all data regarded to a specific record are verified and validated, now the certificate gets ready to be requested and printed. The graduate user can request a certificate by the IHCS web site or by the IHCS mobile application. In the online part, as shown in Figure 1, the graduate user (side of user) needs three steps. In the first step, the user should sign up to gain access to IHCS. The

verification code sent to the graduate email as a second step in order to verify the registration and then the user can sign in to the IHCS. The certificate can be requested when the user provide her/his information in addition to upload personal photo, this is what happens in the step 3. In the side of authority, there are also three steps. In the first step, the authorized employer (certificate issuer) downloads the certificate request(s), which have been requested in the side user. The certificate issuer in the step 2 retrieves the corresponding graduate information from the IHCS database and imports the graduate photo into certificate template in order to edit the final certificate form automatically by the IHCS system. Finally, in the third step the graduate certificate is printed as shown the figure (8).

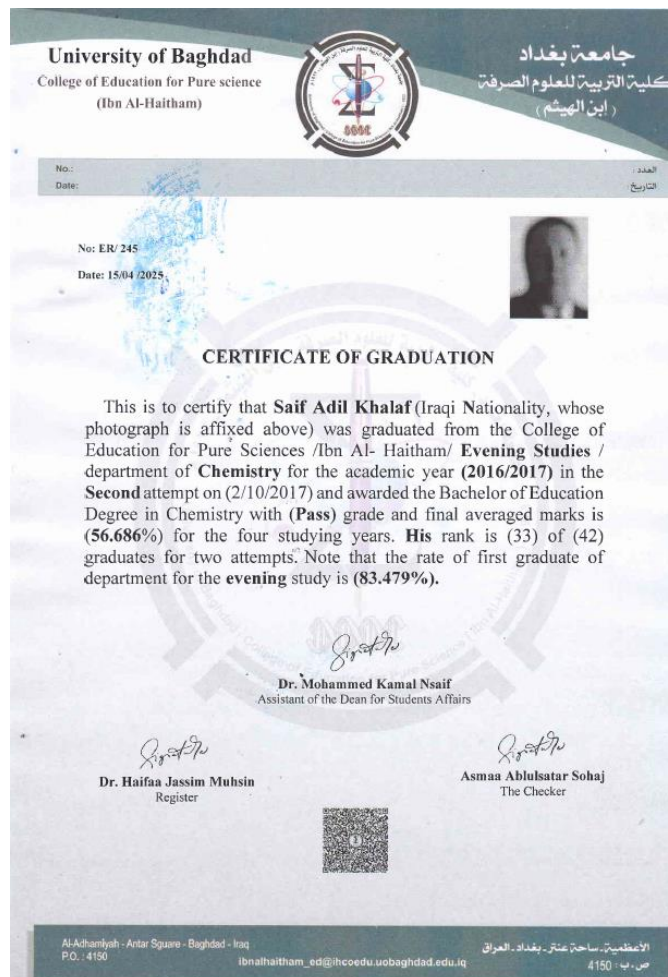


Figure 8. Certificate of graduation that is edited and printed automatically by IHCS

4. Summary of Results

The aim of this project was to develop an automated certificate generation system for college in order to provide fast certificate issuance for students and to reduce the use of paper and saving time. The system was developed using the PHP programming language. The database server for the system was MySQL, and a web browser and web server were used as its user interface. The results of the implementation showed that the IHCS system could generate fast graduate certificates at academic collages, and not like other systems [12] and [13] which are designed to generate event/webinar certificates but not for academic use. The IHCS also provide ability for authorized employee to access to the information of a particular graduate stored in the database by scan the QR code printed in the issued certificate.

Additional results have shown that the features of the IHCS, which are designed in accordance with the required data, are beneficial in all of the expected ways. In the [13] and [15] systems of certificate issuing automation, there are some limitations in data verification, while the IHCS provided efficient operations dedicated for data

verification and validation in order to ensure the correctness of stored data. Furthermore, the certificate was generated by IHCS presents comprehensive data (e.g., student rank, average and photo); which may the graduate depends on it in order to get a job or to have an opportunity to complete a master's or doctoral degree.

Figure (9) shows all uploaded data for six months since the authorized employees in the CEPSIH start to use the IHCS. These results represent the number of database records stored about each graduate in one of five-college department. For example, about 9000 graduate records are uploaded for chemistry department.

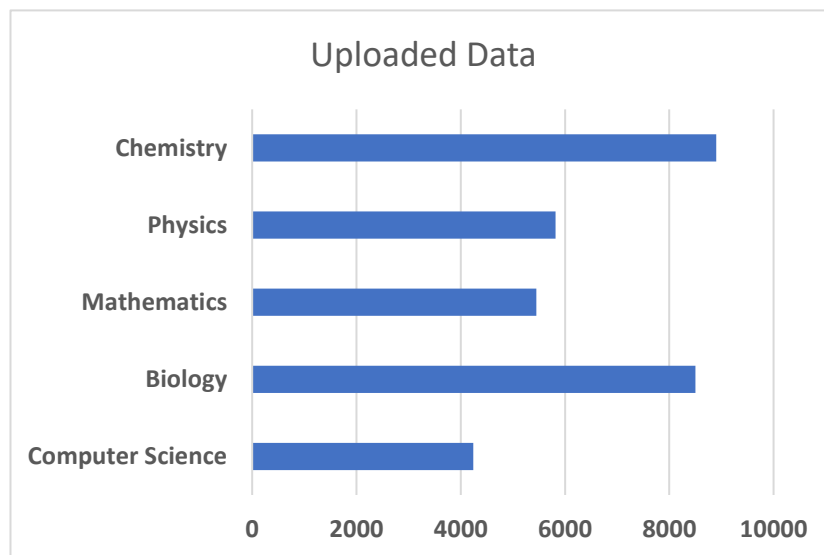


Figure 9. The uploaded data to the IHCS database for five departments in the CEPSIH

Figure (10) illustrates the number of records that are checked by Data-Checker and Data-Validator for the five departments of the college. This means that all information regarded by the checked records are accurate, completed and meets certain standards of the CEPSIH. These results will give a required permission to edit and print certificates for about 32000 graduate students belong to the five different departments.

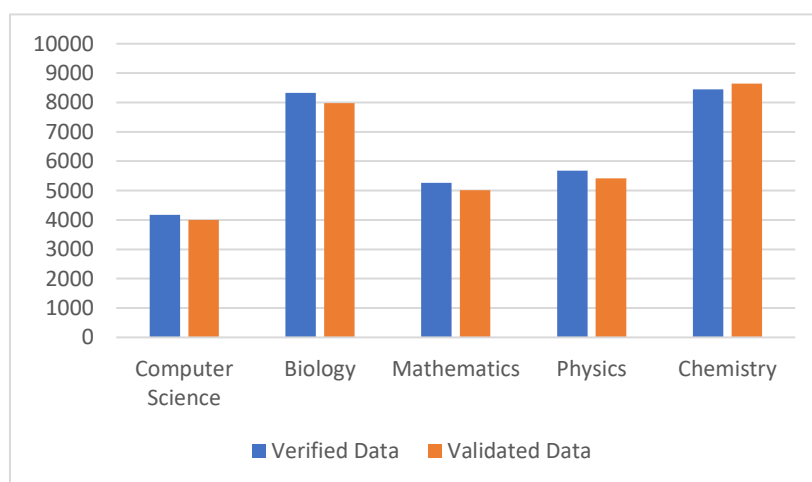


Figure 10. The results of data verification and validation for graduation information

The results in the figure (11) shows the records that are not verified, blocked and under reviewing. The first blue bar, for example, refers to about 50 records belong to the computer science department which are not verified by Data-Checker because there is a problem in the accuracy and completeness of stored data. For this reason, the certificate could not be printed until the Data-Checker gives the permission. The same procedure is followed to the blocked records or to the records, which are under reviewing.

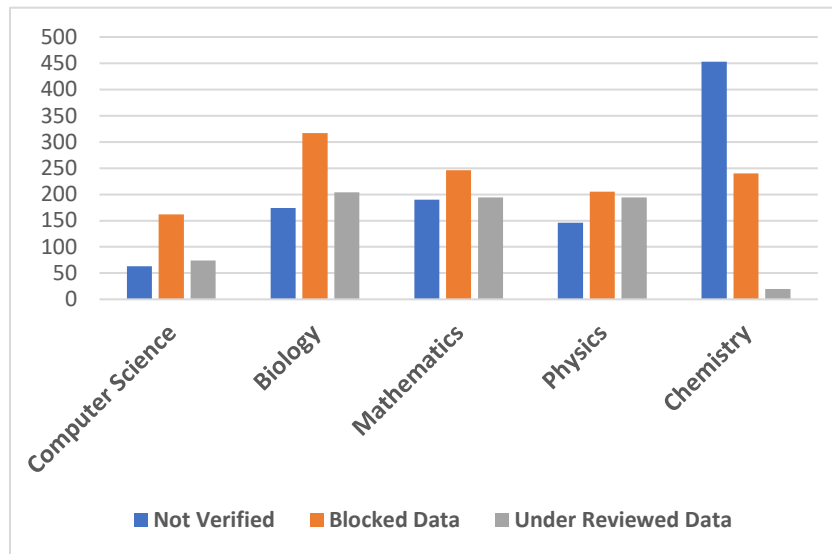


Figure 11. The results for the records that not verified, blocked and under reviewing

5. Conclusion

This research has introduced an advanced manageable certificate generation system called IHCS for certificate generation automation. It has been shown that this is an efficient tool with a high level of satisfaction among many graduates and employees at CEPSIH. It has been noted that this research is a significant step in supporting the CEPSIH to generate the final certificates in a smooth, efficient, and easy way.

Producing the first version of the employability certificate was a great challenge in the CEPSIH. The team of authors has developed this project with features, including the ability to: 1) import CSV files which content graduation information collected from old paper records; 2) verify the accuracy and completeness of stored data; 3) validate each graduate situation that should meet certain standards of the CEPSIH and avoid the risk of making wrong decisions based on incomplete data.

This research provides the first focus in the research community on advanced manageable certificate systems and the needs of colleges especially in Iraqi universities. The implementation of IHCS led up to completely terminate the old paper system. It has achieved the satisfaction of the staff in the registration office, as well as the satisfaction of the students who can now apply online for graduation certificates, saving their time and money. IHCS showed that the certificate cannot be printed even by the authorized employee unless all regarding information were verified and validated. The Data-Checker, for example, has to log in to the IHCS in order to access to the encrypted data stored in the database and implement the data verification.

This research is one of the first of its kind in the Iraqi academic environment. It has offered a real system that helps in managing old big paper archive to gain deep insights for researchers to choose related topics in the future on a wider scale which could be as follows: There is a need to upgrade to a new management information system that will be able to handle the normal administrative practices that take place in the college. Furthermore, the need to student information management: student registration for courses, grades tracking, fees and payment tracking as well as learning management: lectures uploading by instructors, assignments, and exams. Moreover, a significant research is required to be done as a system implemented on cloud database server secured by using blockchain technology to avoid counterfeiting of digital assets.

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