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*Research Article*

# Business Intelligence System for Lecturer Qualification Analysis: Optimizing ETL Workflows for KPI Extraction based on QOX

**Sureena Matayong [a*], Suttida Saebao [b] and Numtip Trakulmaykee [c]**

[a] *Department of Interdisciplinary Engineering, Faculty of Engineering, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.*

[b] *Agricultural Innovation and Management Division, Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.*

[c] *Division of Computational Science, Faculty of Science, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.*

## ABSTRACT

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Evaluating lecturer qualifications is critical for ensuring program compliance with higher education standards in Thailand. This process involves data from multiple sources, leading to redundancy and inaccuracies that complicate data integration and quality, ultimately resulting in delays analysis and decision-making. Business Intelligence (BI) systems are essential for improving data integration and analysis, enabling institutions to make informed decisions through visualizations. However, the effectiveness of these systems relies on a robust Extract, Transform, and Load (ETL) workflow. This study introduces a Quality Objective Matrix (QOX) to evaluate the *accuracy, completeness, scalability, and efficiency* of the workflow. The methodology included analyzing the QOX criteria for workflow development and measurement. Then, the BI system was developed and evaluated using the Technology Acceptance Model (TAM). Results indicated that the ETL workflow achieved 99.99% accuracy, and completeness was measured at 85%. The processing demonstrate significant scalability and efficiency, saving approximately 3 hours and 19 minutes compared to manual methods. User satisfaction scores averaged 4.58 out of 5 with a standard deviation of 0.5 for information quality, perceived ease of use, and perceived usefulness. This study demonstrates that implementing a robust ETL process within a BI system can significantly improve compliance and operational efficiency in higher education institutions.



## 1. Intr oduction

This study extends the work originally presented in (Saebao *et al*., 2020) by designing and developing an Extract, Transform, and Load (ETL) workflow for retrieving and transforming data. The workflow supports the lecturers' qualifications analysis according to Standard Criteria for Graduate Studies Programs (SCGSP), which facilitates the efficient integration of diverse data sources and formats. Building on the previous work, this paper provides additional implementation and evaluation details.

*** Corresponding author.**

***E-mail address:*** *sureena.m@psu.ac.th*

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In recent years, higher education institutions in Thailand have faced significant challenges in assessing compliance with the Higher Education Program Standards B.E. 2565 (Ministry of Higher Education, 2022), particularly in evaluating lecturer qualifications. This complex analysis, which includes criteria such as educational backgrounds, academic positions, advisor workloads, and publication counts (Jansawang *et al*., 2025; Ubachs and Henderikx, 2022), is hindered by the difficulty of extracting and integrating datasets dispersed across multiple repositories with varying structures and formats. Issues of redundancy, inconsistency, and inaccuracy, coupled with the dynamic nature of lecturer information requiring frequent updates, complicate data preparation and maintenance. These challenges consume substantial time and effort, leading to delays in evaluations and undermining accuracy. Consequently, institutions struggle to meet compliance requirements, which can negatively impact their accreditation status and overall academic quality (Chakraborty *et al*., 2021). Addressing these issues is essential to streamline the evaluation process, improve data accuracy, and ensure timely adherence to higher education standards.

Digital technology, particularly Business Intelligence (BI) systems, has emerged as a pivotal tool in addressing challenges related to data integration and analytical capabilities. BI encompasses the utilization of digital computing technologies such as data warehouses, analytics, and visualization tools to identify and analyze essential business data, ultimately generating actionable insights for corporate decision-making (Geetha *et al*., 2020; Chen and Lin, 2021). In the context of higher education, BI contributes significantly to decision-making by enabling academic leaders to monitor and analyze key indicators and trends through various report formats efficiently (Khatir, and Madani, 2024; Mukul and Büyüközkan, 2023; Khatibi *et al*., 2020; Pikhart, 2020; Guan *et al*., 2020; Wang, 2021). However, the success of BI systems is fundamentally tied to the quality of the ETL workflow, which serves as the backbone of data integration and processing (Liu, 2024; Souibgui *et al*., 2019; Theodorou *et al*., 2017; Astriani and Trisminingsih, 2016). The ETL process is responsible for extracting data from heterogeneous sources, transforming it into a consistent and usable format, and loading it into a centralized repository for analysis. While the ETL process streamlines data management, it is often fraught with challenges, including complexity, time consumption, and high costs (Saebao *et al*., 2020; Simitsis *et al*., 2010; Simitsis *et al*., 2009; Awad *et al*., 2011). These challenges are particularly pronounced in higher education, where the integration of diverse data sources is critical for evaluating compliance with standards. A literature review reveals that studies on BI systems can be classified into two main approaches: technical and managerial. The technical approach, highlighted by Niño *et al*. (2020), Awiti *et al*. (2020) and Wang and Liu (2020), emphasizes the development of tools and techniques that facilitate data-driven decision support, including data integration processes and the design of advanced systems. Conversely, the managerial approach focuses on the integration and analysis processes that yield useful information for decision-makers, ensuring the successful implementation of BI systems. Implementations of BI systems have been investigated across various domains, including business (Kleesuwan *et al*., 2010; Niño *et al*., 2020; Girsang *et al*., 2020; Nethravathi *et al*., 2020), healthcare (Gaardboe *et al*., 2017), education (Khatibi *et al*., 2020; Pikhart, 2020; Wang, 2021; Guan *et al*., 2020), and marketing. Notably, the development of BI systems in higher education primarily supports decision-making by integrating relevant information from heterogeneous data sources (Moreno, 2020; Haenlein and Kaplan, 2021). To address the challenges in ETL workflows and BI system adoption, this study introduces a dual approach combining the Quality Objective Matrix (QOX) and the Technology Acceptance Model (TAM). This dual approach addresses both operational and human factors, which not only improves data integration and analysis but also empowers organizations to make timely, informed decisions. Ultimately, it contributes to overcoming the challenges associated with ETL workflows and ensures that BI systems deliver their full potential in higher education.

The QOX framework in this study evaluates ETL workflows across four critical dimensions: accuracy, ensuring correct data transformation in terms of formats, types, and lengths (Azeroual *et al*., 2019; Samir Abdel-Moneim *et al*., 2015; Lucas, 2010; Khan *et al*., 2015; Wand and Wang, 1996; Marshall and De La Harpe, 2009); completeness, verifying that all source data is successfully loaded into the target storage (Azeroual *et al*., 2019; Samir Abdel-Moneim *et al*., 2015; Lucas, 2010; Khan *et al*., 2015; Arputhamary and Arockiam, 2015; Wand and Wang, 1996); scalability, assessing the system's ability to handle increasing data volumes (Simitsis *et al*., 2010; Dayal *et al*., 2009; Arputhamary and Arockiam, 2015); and efficiency, measuring workflow performance in reducing bottlenecks (Simitsis *et al*., 2009; Simitsis *et al*., 2010; Khan *et al*., 2015). While previous studies have acknowledged some dimensions, they often lack depth in exploring scalability and efficiency or fail to integrate them into a comprehensive framework. For instance, research by Dayal *et al*. (2009) and Khan *et al*. (2015) insufficiently examines the relationship between scalability and efficiency, which can lead to delays and resource wastage. Additionally, earlier studies lack practical insights from real-world implementations, limiting their applicability. Complementing this technical optimization, the study employs TAM to evaluate user satisfaction and adoption. TAM, developed by Davis (1989), consists of two key factors: perceived usefulness, reflecting the belief that a system enhances job performance, and perceived ease of use, relating to the minimal effort required to use the system (Wang and Song, 2017; Cho *et al*., 2020; Xu and Du, 2019). These factors positively influence user satisfaction and technology acceptance (Wang and Song, 2017; Cho *et al*., 2020; Xu and Du, 2019). However, this study expands TAM by integrating information quality, which is assessed through accuracy, timeliness, reliability, relevance, integrity, and simplicity as a third factor, offering a more comprehensive understanding of user satisfaction drivers (Ashfaq *et al*., 2020; Koivumaki *et al*., 2008; Wang and Teo, 2020). By synergizing perceived usefulness, perceived ease of use, and information quality, this framework aims to improve the design and implementation of technology solutions, ensuring they meet user needs and enhance overall satisfaction. The research objectives are as follows:

- To optimize the ETL workflow using QOX to enhance system performance.
- To assess user satisfaction and technology acceptance through the TAM to ensure usability and adoption.

The methods employed in this study focus on:

- Developing and evaluating ETL workflows to address redundancy, inconsistency, and inefficiency.
- Implementing the QOX framework to measure and improve key performance indicators.
- Applying TAM to gather user feedback and refine the system for better alignment with user needs and satisfaction.

## 2. Materials and Methods

The study followed a research and development approach to ensure a holistic evaluation of both technical and user-focused elements, enhancing the system's performance and usability. The methodology was organized into five sequential steps, as depicted in Figure 1: (1) analyze SCGSP qualification criteria and data sources, (2) design and develop the ETL workflow, (3) evaluate the ETL workflow based on QOX, (4) design and develop the BI system, and (5) evaluate the user's satisfaction based on TAM.

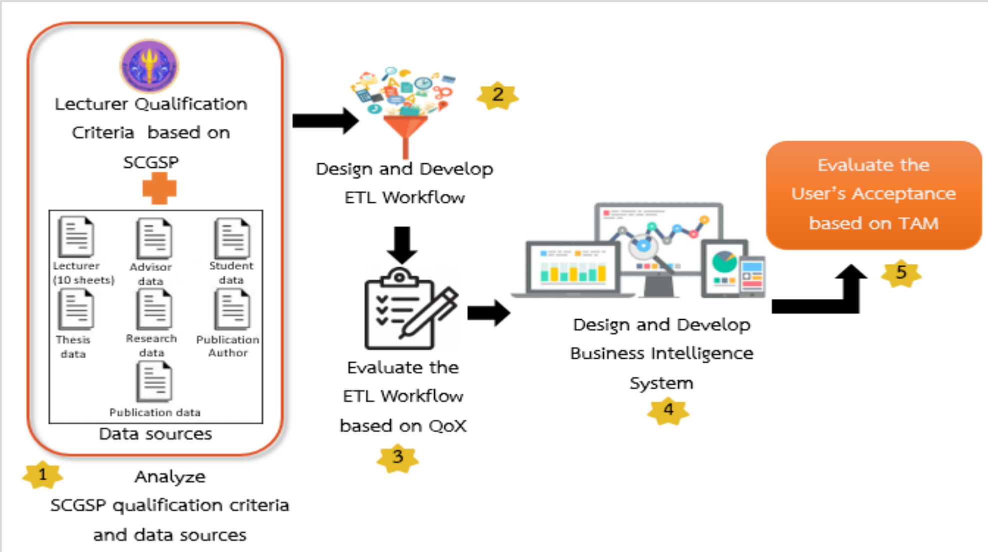


**Figure 1** The Methodology

**Table 1** Role of lecturers and data sources

| Data | Role | | |
|---|---|---|---|
| | Lecturer | Curriculum Instructor | Advisor |
| Educational qualifications | | | |
| - Field of study | ✓ | ✓ | ✓ |
| - Year of graduation | | | |
| Academic position | ✓ | ✓ | ✓ |
| Academic achievements | ✓ | ✓ | ✓ |
| Information on the type of current teaching staff | | | |
| - Courses in which the faculty is a regular faculty member | ✓ | ✓ | ✓ |
| - Courses in which the faculty is responsible for the course | | | |
| Information on the appointment of the main thesis advisor/students under supervision | - | - | ✓ |

*2.1 Analyze SCGSP Qualification Criteria and Data Sources*

According to the Higher Education Program Standards B.E. 2565 (Ministry of Higher Education, 2022), the lecturer qualifications benchmark for Component 1 focuses on the number and qualifications of lecturers. For the benchmark analysis, three roles must be evaluated based on different criteria, as outlined in Table 1. The roles of lecturer and curriculum instructor do not require an assessment of dissertation advisor workload, whereas the dissertation advisor's role does. However, all roles must consider criteria related to educational background, academic position level (e.g., Assistant Professor, Associate Professor, Professor), publication record, and advisor workload.

To analyze the data sources effectively, the selection process involved a rigorous review of the literature and collaboration with domain experts to identify the most relevant and critical datasets that comply with the criteria of Higher Education Program

Standards B.E. 2565 (Ministry of Higher Education, 2022). The specific criteria used for selection included data relevance, completeness, accuracy, and accessibility. This approach ensured that the selected data sources not only met the fundamental requirements of quality and relevance but also aligned with the specific educational standards set forth for higher education programs. By systematically considering compliance with these standards, the analysis aimed to reinforce the integrity and effectiveness of the data used in the research, thereby contributing to enhanced educational outcomes and adherence to established regulations. At this stage, the data is scattered across various unstructured formats, such as documents, Excel files, and other file types, collected from three primary sources: the Curriculum of Faculty (CF), the Registration System (RS), and the Graduate School (GS). To prepare the data for the ETL workflow, a systematic process was implemented. Raw data from diverse sources was collected, structured into defined datasets and schemas, and organized into Excel files to establish a preliminary structure. A unified data schema was then created in Excel to ensure consistency, compatibility, and seamless integration across varying formats. This step was essential for transforming unstructured data into a structured format, enabling efficient analysis and integration within the ETL process. This study developed seven" important datasets that related to lecturer's qualification criteria: (1) lecturer profile, (2) advisor data, (3) student data, (4) thesis data, (5) research data, (6) publication author, and (7) publication data. The schemas for these datasets were derived through a combination of extraction and definition processes. The element names (schemas) in each table, as shown in Tables 2-8, were carefully analyzed and extracted from the available data. Where necessary, they were redefined to enhance clarity and consistency across all datasets.

*2.2 Design and Develop ETL Workflows*

Three ETL workflows were designed and developed in this study using SQL Server Integration Services (SSIS) via Visual Studio 2019. SSIS provides the necessary tools to efficiently extract data from various sources namely CF, RS, and GS databases, transforming this data into a standardized format suitable for analysis. Its robust capabilities ensure that large volumes of data are processed accurately and efficiently, which is essential for timely decision-making.

**Table 2** Schema lecturer profile data (CF)

| No. | Schema | Descriptions |
|---|---|---|
| 1 | NAME_THAI | Name and Surname in Thai |
| 2 | NAME_ENG | Name and Surname in English |
| 3 | STAFF_ID | Staff Number |
| 4 | POSITION | Academic Position |
| 5 | POSITION_LEVEL | Position Level |
| 6 | START_DATE | Date of Employment |
| 7 | EDU_LEVEL_ENG | Highest Education History |
| 8 | BIRTH_DATE | Day/Month/Year of Birth |

**Table 3** Schema advisor data (GS)

| No. | Schema | Descriptions |
|---|---|---|
| 1 | ID_CARD | Teacher's national ID card number |
| 2 | ADVISOR_POSITION | Advisor's position code |
| 3 | POSITION_NAME | Advisor's position name in Thai |
| 4 | POSITION_NAME_ENG | Advisor's position name in English |
| 5 | ADVISOR_ORDER-DATE | Date of appointment of advisor |

**Table 3** (Continuous)

| No. | Schema | Descriptions |
|---|---|---|
| 6 | STUDENT_ID | Student ID |
| 7 | ENT_TERM | Semester of study |
| 8 | ENT_YEAR | Academic year of study |
| 9 | STUDENT_NAME | Thai student name |
| 10 | STUDENT_NAME_ENG | English student name |
| 11 | FAC_ID | Faculty code of student's affiliation |
| 12 | FAC_NAME_THAI | Faculty name of student's affiliation |
| 13 | CMAM_ID | Campus code |
| 14 | CAMP_NAME_THAI | Campus name of student |
| 15 | STUDY_STATUS | Education status code |
| 16 | STUDY_STATUS_DETAIL | Education status code name |
| 17 | STILL_STUDENT | Student status |

**Table 4** Schema student data (RS)

| No. | Schema | Descriptions |
|---|---|---|
| 1 | STUDENT_ID | Student ID |
| 2 | STUDENT_NAME | Student name in Thai |
| 3 | STUDENT_NAME_ENG | Student name in English |
| 4 | CARD_ID | Student ID number |
| 5 | MAJOR_ID | Major code |
| 6 | MAJOR_NAME_THAI | Major name in Thai |
| 7 | MAJOR_NAME_ENG | Major name in English |
| 8 | DEEGREE_NAME_THAI | Degree name |
| 9 | COURSE_TYPE_ID | Program type code |
| 10 | COURSE_TYPE_NAME | Major type name |
| 11 | STUDY_TYPE_ID | Study type code |
| 12 | STUDY_TYPE_NAME | Study type name |
| 13 | PLAN_ID | Study plan code |
| 14 | PLAN_NAME_TH | Study plan name in Thai |
| 15 | PLAN_NAME_ENG | Study plan name in English |
| 16 | FIELD_ID | Sub-major code |
| 17 | FIELD_NAME_TH | Sub-major name in Thai |
| 18 | FIELD_NAME_ENG | Sub-major name in English |
| 19 | DEPT_ID | Department code |
| 20 | DEPT_NAME_THAI | Department name in Thai |
| 21 | DEPT_NAME_ENG | Department name in English |
| 22 | EDU_LEVEL | Faculty code of student's home faculty |
| 23 | EDU_LEVEL_TH | Thai level name |
| 24 | EDU_LEVEL_ENG | English level name |
| 25 | CAMP_ID | Campus code |
| 26 | CAMP_NAME_THAI | Campus name of student |
| 27 | STUDY_STATUS | Education status code |

**Table 4** (Continuous)

| No. | Schema | Descriptions |
|---|---|---|
| 28 | STUDY_STATUS_NAME | Education status code name |
| 29 | ENT_DATE | Entry date |
| 30 | ENT_TERM | Section of entry |
| 31 | ENT_YEAR | Academic year of entry |
| 32 | GRAD_DATE | Graduation date or termination of student status |
| 33 | GRAD_TERM | Section of graduation |
| 34 | GRAD_YEAR | Academic year of graduation |
| 35 | FOREIGN | Student type T Thai F International |
| 36 | STILL_STUDENT | Student status |

**Table 5** Schema thesis data (GS)

| No. | Schema | Descriptions |
|---|---|---|
| 1 | STUDENT_ID | Student ID |
| 2 | STUDENT_NAME | Student Name |
| 3 | ADVISOR_NAME | Thesis Advisor Name |
| 4 | ID_CARD | Teacher's National ID Card Number |
| 5 | STAFF_ID | Thesis Advisor Personnel ID |
| 6 | THESIS_TITLE_TH | Thai Thesis Name |
| 7 | THESIS_TITLE_ENG | English Thesis Name |
| 8 | THESIS_TITLE_EXAM | Thesis Outline Exam Date |
| 9 | THESIS_EXAM_DATE | Thesis Defense Exam Date |
| 10 | EXAM_ID | Thesis Defense Exam Times |
| 11 | EXAM_TIME | Thesis Defense Exam Time |
| 12 | EXAM_PLACE | Thesis Defense Exam Location |
| 13 | RESULT_EXAM | Thesis Exam Result Code |
| 14 | RESULT_DETAIL | Thesis Exam Result |
| 15 | THESIS_ACCEPT_DATE | Thesis Booklet Receipt Date |
| 16 | GS_GRAD_DATE | B.W. Graduation Date |

**Table 6** Schema research data (CF)

| No. | Schema | Descriptions |
|---|---|---|
| 1 | AW_NO_ID | Author Work ID |
| 2 | NAME_THAI | Thai Author Name |
| 3 | NAME_ENG | English Author Name |
| 4 | ID_CARD | Author Identification Number |
| 5 | RESEARCH_ID | Research ID |
| 6 | RESEARCH_NAME | Research Name |

**Table 7** Schema publication author (CF)

| No. | Schema | Descriptions |
|---|---|---|
| 1 | AT_ID | Author ID |
| 2 | AW_NO_ID | Author Work ID |
| 3 | NAME_THAI | Thai Author Name |
| 4 | NAME_ENG | English Author Name |
| 5 | ID_CARD | Author Identification Number |
| 6 | MTYPE_ID | Academic Work Type |
| 7 | TYPE_ID | Author Type Code 1: Main Author 2: Co-Author |
| 8 | AT_PERCENT | Percentage of Work |

**Table 8** Schema publication data (CF)

| No. | Schema | Descriptions |
|---|---|---|
| 1 | AW_NO_ID | Academic work code |
| 2 | LANGUAGE | Language used |
| 3 | AUTHOR_AMOUNT | Number of authors |
| 4 | END_YEAR | Year of work |
| 5 | NAME_THAI | Thai title of work |
| 6 | NAME_ENG | English title of work |
| 7 | JOURNAL_THAI | Thai journal name |
| 8 | JOURNAL_ENG | English journal name |
| 9 | VOLUM | Journal issue |
| 10 | NO | Volume of journal |
| 11 | START_PAGE | Starting page |
| 12 | END_PAGE | Ending page |
| 13 | PRESENT-YEAR | Year of academic conference |
| 14 | CONFERENCE_THAI | Thai conference name |
| 15 | CONFERENCE_ENG | English conference name |
| 16 | CITY_THAI | Thai conference city name |
| 17 | CITY_ENG | English conference city name |
| 18 | PLACE_THAI | Thai presentation venue name |
| 19 | PLACE_ENG | English presentation venue name |
| 20 | RECORD_DATETIME | Date and time of data recording |

The first workflow, LecProfile, prepared data about lecturer's profile from 10 departments. The second workflow, LecAdvisor, processed data related to dissertation advisors by extracting files from the 'Advisor', 'Student', 'Thesis' and 'Lecturer' datasets. Finally, the LecPublication workflow compiled data on lecturers' publications using three data files: 'Research', 'Publication Author', and 'Publication'.

Figure 2 shows an example of the ETL workflow for LecProfile. The data is imported from two sources: (1) personnel data from the CF (2) current roles. The current roles files cannot be directly analyzed due to its data storage format. Therefore, the data must be augmented by adding attributes that identify the types of each role. Additionally, the personnel database in the CF requires extra attributes to enable data linking with other databases. Following these steps, the data will be managed using the ETL workflow process below.

The example processes of LecProfile workflow were shown in the following steps:

- Combining the 10 sheets of 10 lecturer departments into a single dataset using the 'Union All' command as presented in Figure 2.
- Deleting the empty data row that contains a blank data value in the ID_CARD attribute.

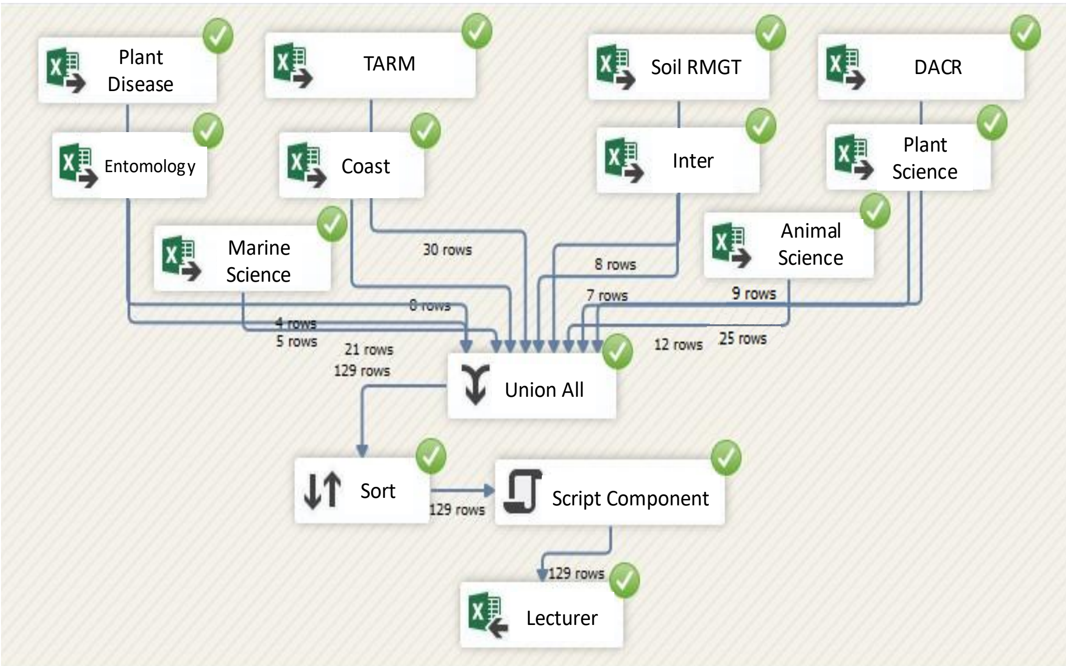


**Figure 2** The example ETL workflow of LecProfile

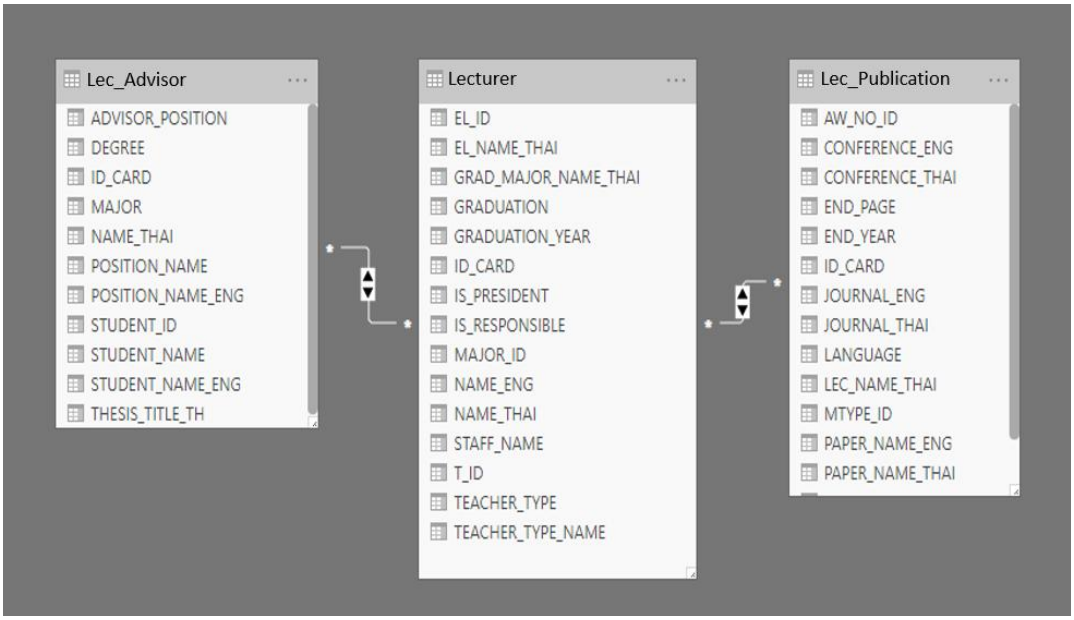


**Figure 3** The result files from ETL workflow

- Replacing values of some mismatched data, such as the graduated year, where year values were not in A.D. and were replaced from B.E. to A.D., and the teacher type (L and C) which were replaced with '1' and '2', respectively.

After all the ETL workflows were run, three result files were generated: Lec_Advisor, Lecturer, and Lec_Publication as shown in Figure 3.

*2.3 Evaluate the ETL Workflow based on QOX*

In this study, the QOX evaluation focused on four key aspects: accuracy, completeness, scalability, and efficiency.

*2.3.1 Accuracy*

Accuracy served as a critical performance indicator to assess the ETL workflow. It ensured that data was accurately loaded into the target system as expected. Using value mapping comparisons, SQL set operators were employed to verify data type, length, range, and unique values of critical fields between the source and target systems. For precise evaluation, 80% of the source data was sampled five times and tested across each ETL workflow. If the mapping results matched in both data and type between sources and targets, the workflow was deemed accurate.

*2.3.2 Completeness*

Completeness aimed to confirm that all expected data was transferred from the source to the target. Two primary tests were conducted: (1) comparing the number of rows between the source and target, and (2) validating necessary attributes for missing or incorrect values. Three algorithms were designed for testing completeness across the workflows: Algorithm 1 for LecProfile, Algorithm 2 for LecAdvisor, and Algorithm 3 for LecPublication. Each workflow included a 'Script Component' node to execute the completeness evaluation, producing results such as row counts in the source and target files, missing data counts, and completeness values.

*2.3.3 Scalability*

Scalability measures the ETL workflow's ability to handle increased data volumes efficiently. To test scalability, this study expanded the source data to 5 and 10 times the original row count (where x represents the initial number of rows) and re-ran the ETL workflows. If the workflows executed within acceptable timeframes, they were deemed scalable.

**Algorithm 1:** Completeness evaluation of LecProfile workflow

```
Result: row count of source, row count of target, row count of missing data,
        completeness value
missing_data = 0;
ii = 1;
count_source = 0;

 while (ii < 11) do
    rowDepartment_ii = count(row in sheet_ii);
    count_source = count_source + rowDepartment_ii;
    ii = ii + 1;
 End
SELECT count(ID_CARD) as count_target FROM Lecturer;
differ_rows = count_source - count_target;
completeness = 1 - (differ_rows/count_source);
while not EOF of Lecturer do
    if (ID_CARD is null or STAFF_NAME is null) or
       (EL_ID is null or GRADUATION is null)
    then
       missing_data = missing_data +1;
    end
end
Display count_source, count_target, missing_data, completeness;
```

**Algorithm 2:** Completeness evaluation of LecAdvisor workflow

```
Result: row count of source, row count of target, row count of missing data,
        completeness value
missing_data = 0;
SELECT count(ID_CARD) as count_source FROM Advisor;
SELECT count(ID_CARD) as count_result FROM Lec_Advisor;
differ_rows = count_source - count_target;
completeness = 1 - (differ_rows/count_source);
while not EOF do
    if ((THESIS_TITLE_ENG is null and THESIS_TITLE_TH is null) or
       (ID_CARD is null or ADVISOR_POSITION is null)) or
       (STUDENT_ID is null or DEGREE is null)
    then
       missing_data = missing_data +1;
    End
End
Display count_source, count_result, missing_data, completeness;
```

**Algorithm 3:** Completeness evaluation of LecPublication workflow

```
Result: row count of source, row count of target, row count of missing data,
        completeness value
missing_data = 0;
SELECT count(AW_NO_ID) as count_source FROM Publication;
SELECT count(AW_NO_ID) as count_target FROM Lec_Publication;
differ_rows = count_source - count_target;
completeness = 1 - (differ_rows/count_source);
while not EOF do
    if ((CONFERECE_ENG is null and CONFERECE_THAI is null) and
       (JOURNAL_ENG=null and JOURNAL_THAI is null)) or
       ((PAPER_NAME_ENG is null and PAPER_NAME_THAI is null) or
       (MTYPE_ID is null or ID_CARD is null))
    then
       missing_data = missing_data +1;
    end
end
Display count_source, count_target, missing_data, completeness;
```

*2.3.4 Efficiency*

Efficiency evaluates the ETL workflow's resource optimization, focusing on minimizing both time and materials both time and materials while achieving the desired outputs. For this assessment, the total execution time of the three proposed ETL workflows was calculated and compared to a manual-based system, which involved human data preparation without workflow software. The manual system averaged 3 hours and 35 minutes, while the proposed ETL workflows demonstrated significantly reduced execution times, highlighting their efficiency. This comparison underscores the time-saving benefits and resource optimization of the automated ETL approach.

*2.4 Design and Develop Business Intelligence System*

The Lecturer Qualification Analysis System (LQAS) was developed to support decision-making based on SCGSP criteria regarding curriculum instructor and advisor allocation. Microsoft Power BI was utilized to design and develop data visualizations. It supports a wide range of data connectors, enabling seamless integration with multiple data sources and facilitating real-time data access. Its advanced data modeling features allow for complex calculations and measures, providing deeper insights into lecturer qualifications through interactive reports and dashboards. Before creating data visualizations, a data model was developed to establish relationships between entities and to prepare the dimensions for visualization. The main dashboard presents an overview of the number of lecturers eligible to serve as curriculum instructors and major advisors, both currently and in the future, as shown in Figure 4. This data visualization allows filtering based on various conditions, such as curriculum, lecturer roles, types of advisors, and year ranges. Additionally, it illustrates the total number of lecturers, theses, major advisors, co-advisors, and publications. The dashboard also leverages useful BI features, such as drill-down and drill-through functionalities.

The 'drill through' feature allows users to access additional dashboards for further insights. Figure 5 illustrates a dashboard displaying a list of lecturers and their workloads, which can be accessed by drilling through from the bar chart in Figure 4. Similarly, the dashboard in Figure 6 allows users to drill through from the list of lecturers in Figure 5 to view detailed information about each lecturer, including their name, major, education, email, role, list of advisees, and list of publications.

Additionally, users can click on visuals to 'drill down' and explore the next level of hierarchical data. Figure 7 demonstrates the drill-down interaction on the publication bar chart from Figure 6, revealing the breakdown of publications by language (THA for Thai and ENG for English) for each year.

*2.5 Evaluate the User's Satisfaction*

The study population comprised academic and support staff involved in curriculum management and required to use the system. To evaluate user satisfaction, an online questionnaire was distributed to 44 individuals related to curriculum management. The questionnaire was divided into three parts: (1) participant profiles, including gender, education level, and roles (e.g., lecturer, curriculum instructor, Graduate School officer); (2) factors influencing user satisfaction, such as information quality, perceived ease of use, and perceived usefulness, assessed using a 5-point Likert scale (1 = not satisfied, 5 = very satisfied); and (3) a section for additional suggestions. For statistical analysis, the SPSS program was utilized to compute descriptive statistics, including mean, standard deviation, and frequency, providing insights into user satisfaction levels and feedback.

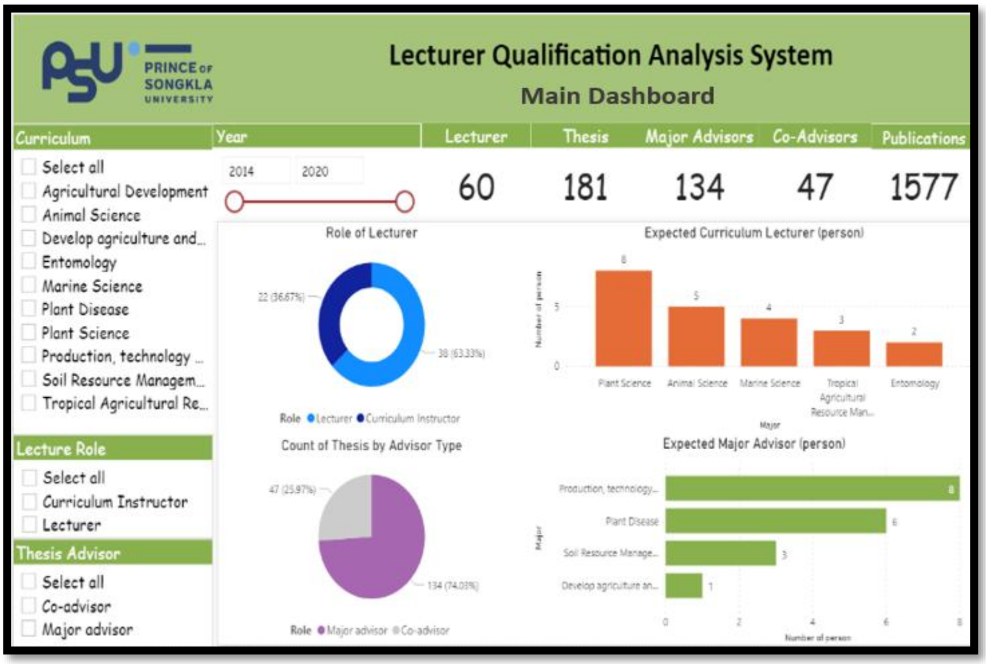


**Figure 4** The main dashboard

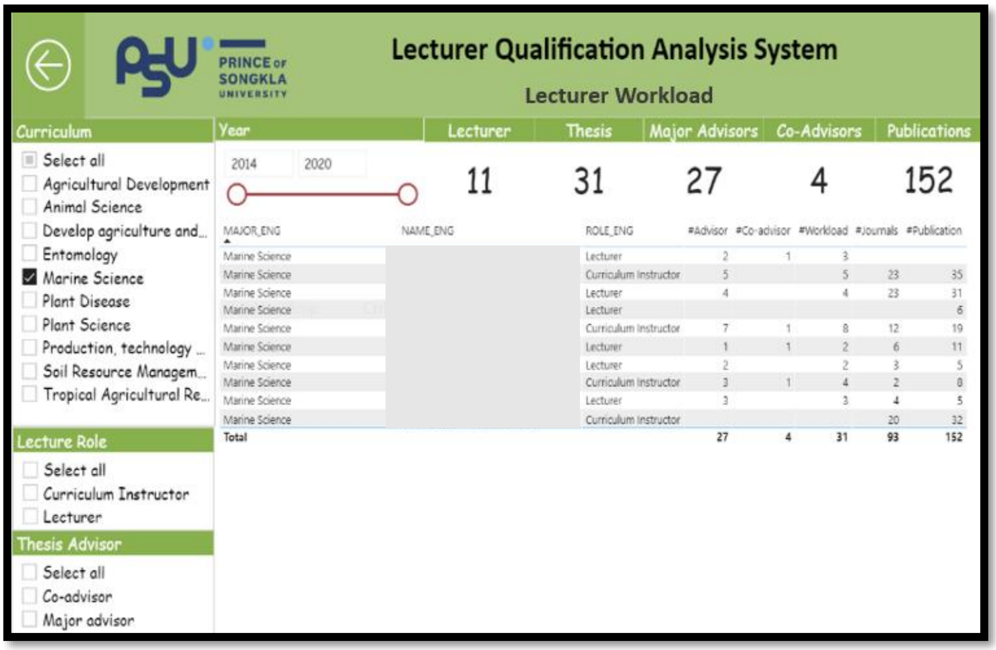


**Figure 5** The list of lecturers and workload dashboard from drill thought method

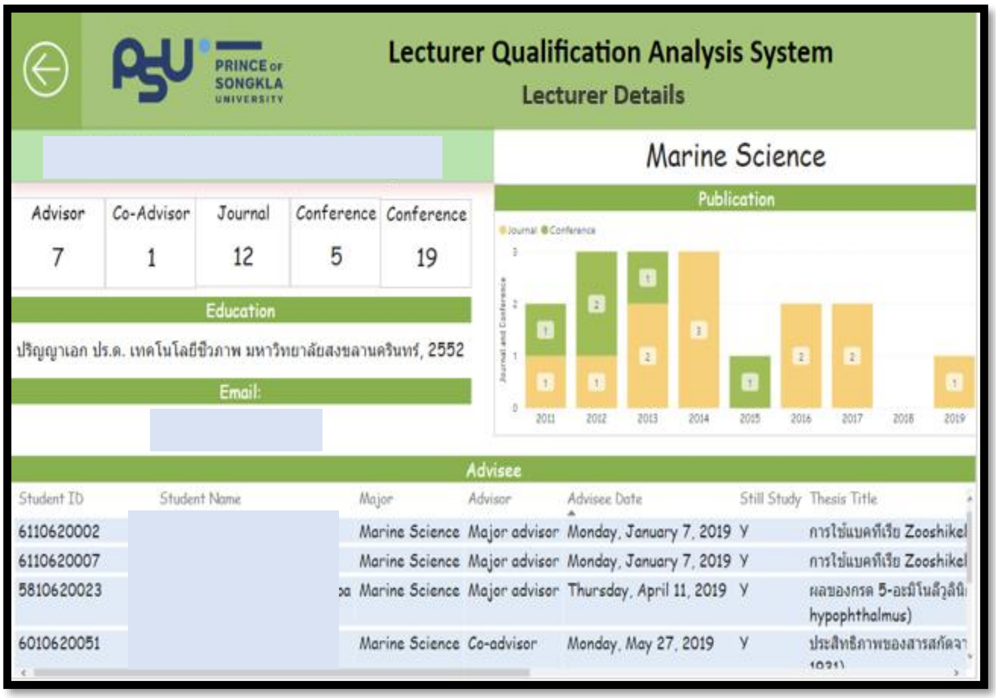


**Figure 6** The details of lecturer dashboard from drill thought interaction

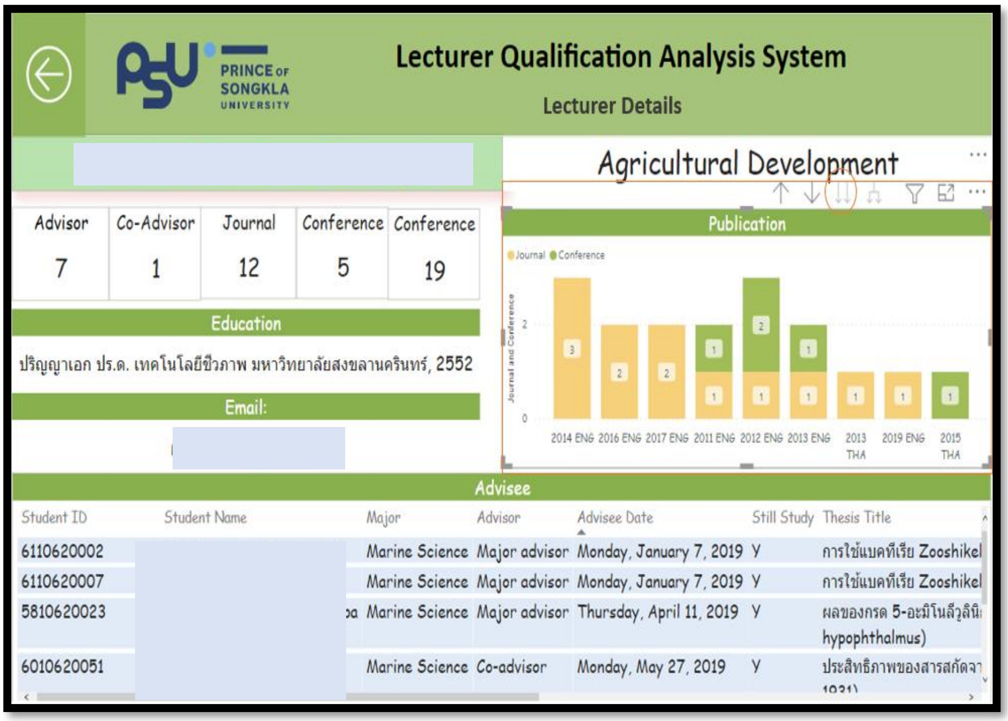


**Figure 7** The example of drill down data in the publication bar chart

## 3. Results and Discussion

This section consisted of two main evaluations: (1) the quality of ETL workflows, and (2) users' satisfaction.

*3.1 Results of ETL Workflow based on QOX*

In this study, the quality evaluation of the designed ETL workflow was based on four key dimensions: accuracy, completeness, efficiency, and scalability.

*3.1.1 Accuracy*

For accurate testing, the data provided through simple random sampling was run in each ETL workflow and compared using mapping method as presented in Figure 8. The results compared five times, showed the accuracy mappings, even though the data sets were different. Testing the ETL workflow across all three instances, with five runs, revealed an average accuracy rate of 99.99% as shown in Table 9. The findings demonstrate a high accuracy rate of 99.99%, which aligns with recent research in BI systems that utilize other approach such as machine learning models. For instance, studies conducted by Bony *et al*. (2024), Biaojun *et al*. (2021), Wang (2023), and Susilo and Susanto (2024) reported accuracy levels ranging from 85% to 98%. This consistency highlights the effectiveness of this BI system. The results demonstrate that the accuracy achieved falls within the accepted range established by previous research, confirming the effectiveness of the methodology of this study.

**Table 9** The experiment results of accuracy

| ETL | Accuracy running tests | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **%** |
| LecProfile | 100 | 100 | 100 | 100 | 100 | 100 |
| LectAdvisor | 100 | 100 | 100 | 100 | 100 | 100 |
| LecPublication | 99.98 | 99.98 | 99.98 | 99.98 | 99.98 | 99.98 |
| **Average** | **99.99** | **99.99** | **99.99** | **99.99** | **99.99** | **99.99** |

**Table 10** The experiment results of completeness

| ETL Workflow | Source file (rows) | Target file (rows) | Missing data (rows) | Completeness (0 – 1) |
|---|---|---|---|---|
| LecAdvisor | 181 | 181 | 0 | 1 |
| LecProfile | 129 | 129 | 15 | 0.88 |
| LecPublication | 2,086 | 2,086 | 310 | 0.85 |

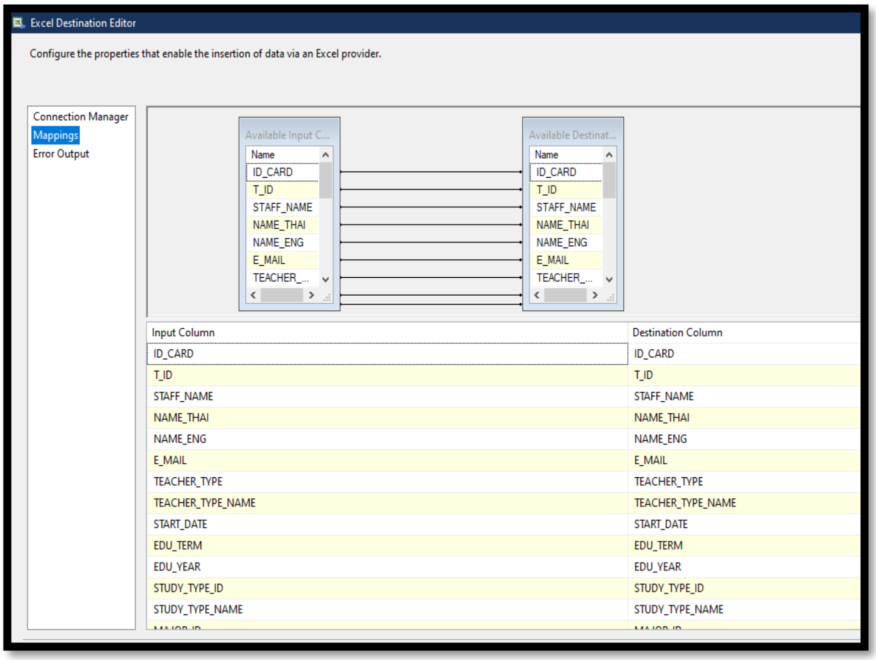


**Figure 8** The example mapping comparison between source and target

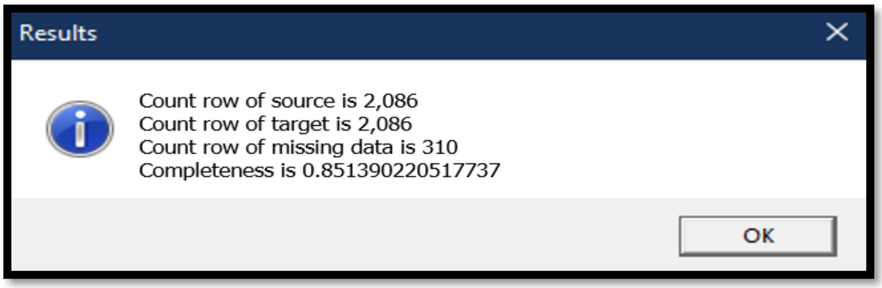


**Figure 9** The results of completeness evaluation in LecPublication workflow

*3.1.2 Completeness*

For the completeness evaluation, the study systematically analyzed the number of rows in both the source and target files, identified rows with missing data, and calculated the completeness value for each ETL workflow. Initial results revealed a completeness value of 85%, with Figure 9 illustrating the evaluation outcomes for the LecPublication workflow. Table 10 presents the experimenta results, showing that the LecAdvisor workflow achieved a completeness value of 1, indicating optimal completeness. However, the LecProfile and LecPublication workflows initially recorded completeness values below 1 due to missing data in

the source files. To address this issue, the ETL workflow scripts were modified to include conditions for handling null values, excluding rows with null values from the missing data count. After these adjustments, all three workflows-LecAdvisor, LecProfile, and LecPublication-achieved a completeness value of 1 in the final run. This demonstrates that the ETL workflow, when properly optimized, can deliver high completeness in data management. When compared with the literature, the initial completeness value of 85% falls within the acceptable range reported in similar studies. For instance, Zineb and Rachid (2023) and Cheruku *et al*. (2024) highlighted challenges of obtaining complete datasets from diverse sources, aligning with the findings of this study. The subsequent modifications to the ETL workflow, which improved the completeness value to 1, underscore the effectiveness of tailored data management strategies in enhancing data quality. Achieving a completeness value of 1, as seen in the LecAdvisor workflow, corroborates previous research findings, which suggest that well-designed ETL solutions can effectively mitigate data quality issues related to completeness. These improvements not only enhance the integrity of the data being analyzed but also support more reliable decision-making processes, which are critical for the success of BI systems.These insights emphasize the importance of continuous refinement of ETL processes to ensure high data quality. Future research will explore the impact of specific ETL modifications on completeness and other data quality dimensions across various contexts, with ongoing efforts to refine and improve these metrics in future iterations.

*3.1.3 Scalability*

For the scalability experiment, the number of rows in each ETL workflow was increased by 5 times and 10 times, as presented in Table 11. The results of all compiled experiments demonstrated success, indicating that the workflows maintained their performance even with the increased data volume. Specifically, the execution times for the LecAdvisor and LecPublication workflows increased proportionally with the number of additional rows. In contrast, the execution time for the LecProfile workflow did not increase significantly, likely due to its simpler algorithm and flow. Despite the increases in data volume, the total execution time across all three ETL workflows remained less than a minute. This finding suggests that the ETL workflows developed in this study exhibit scalability in terms of running time. When comparing the scalability results to previous research, the workflows' ability to efficiently handle increased data loads aligns with findings from studies like those by Cheruku *et al*. (2024) and Gueddoudj and Chikh, (2023), which emphasize the importance of scalable architecture in ETL processes.

**Table 11** The experiment results of scalability

| ETL workflow | Raw data from sources | | Increasing rows | | |
|---|---|---|---|---|---|
| | Number of rows | Usage time (Sec) | Increasing rows | Compiled results | Usage time (Sec) |
| LecAdvisor | 3,408 | 3.49 | 5x | ✓ | 15.05 |
| | | | 10x | ✓ | 24.64 |
| LecProfile | 129 | 3.81 | 5x | ✓ | 4.05 |
| | | | 10x | ✓ | 4.50 |
| LecPublication | 3,705 | 8.66 | 5x | ✓ | 14.08 |
| | | | 10x | ✓ | 17.17 |

Their research indicates that efficient ETL systems can process larger datasets with minimal impact on performance, similar to the outcomes observed in this study. Additionally, the scalability demonstrated in our workflows aligns with insights from Szilveszter *et al*. (2024), who highlighted that well-designed ETL workflows can adapt to growing data volumes without significant performance degradation. These comparisons underscore the effectiveness of our ETL design, affirming that it not only meets current data processing needs but is also well-prepared to handle future demands as data volumes continue to expand. Overall, these results reinforce the notion that scalability is a crucial attribute of ETL workflows, ensuring that organizations can maintain high performance levels despite increasing data challenges. Future studies could delve deeper into specific aspects of scalability to uncover potential optimizations and further enhance the efficiency of ETL processes across different applications.

*3.1.4 Efficiency*

In the efficiency evaluation, experiments were conducted to measure the computing time for each ETL workflow, as presented in Figure 10 and Table 12. The workflow running times for LecAdvisor, LecProfile, and LecPublication were 3.49, 3.81, and 9.85 minutes, respectively, totaling 17.15 minutes for total all three workflows combined. Compared to the manual-based system, which took approximately 3 hours and 19 minutes, the ETL workflows demonstrated significant time savings. This result clearly indicates that preparing data with the ETL workflow is far more efficient than using a manual-based system. These efficiency gains highlight the benefits of automating data processing tasks, enabling faster execution and freeing up valuable time that can be redirected toward more strategic activities. When compared to previous research, these findings are consistent with studies that emphasize the efficiency improvements offered by ETL processes. For example, Cheruku *et al*. (2024) and Mayuk *et al*. (2021) discuss how automation in ETL can substantially reduce data processing times, an observation that is corroborated by our results. This dramatic reduction in processing time underscores the potential of ETL systems to streamline operations and enhance productivity. Overall, the efficiency of our ETL workflows not only reduces time consumption but also minimizes the likelihood of human error, further strengthening the reliability and accuracy of data processing. Future research could explore additional techniques or technological advancements that could further improve the efficiency of ETL workflows, thus providing even greater benefits in data management and analysis.

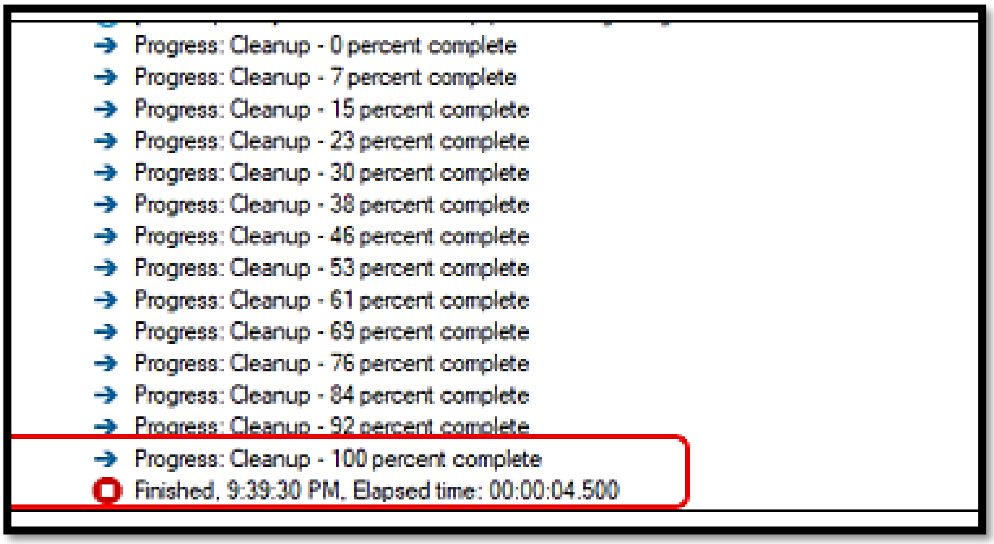


**Figure 10** The example screen of ETL processing

**Table 12** The experiment results of efficiency

| **ETL** | **Runtime Duration (Seconds)** | | |
|---|---|---|---|
| **Times running** | **LecProfile** | **LecAdvisor** | **LecResearch** |
| 1 | 3.03 | 2.58 | 4.00 |
| 2 | 3.24 | 2.58 | 22.19 |
| 3 | 3.00 | 2.81 | 22.15 |
| 4 | 3.08 | 3.52 | 8.63 |
| 5 | 3.02 | 2.53 | 21.94 |
| 6 | 3.02 | 2.49 | 16.50 |
| 7 | 2.98 | 16.93 | 2.11 |
| 8 | 3.36 | 2.75 | 2.13 |
| 9 | 2.81 | 2.53 | 2.14 |
| 10 | 2.94 | 2.66 | 16.51 |
| 11 | 3.34 | 2.89 | 2.27 |
| 12 | 3.13 | 2.50 | 16.68 |
| 13 | 3.16 | 2.50 | 16.67 |
| 14 | 17.11 | 2.95 | 2.28 |
| 15 | 3.34 | 2.93 | 16.64 |
| 16 | 3.06 | 2.58 | 1.92 |
| 17 | 3.27 | 2.50 | 1.91 |
| 18 | 3.17 | 2.60 | 16.29 |
| 19 | 2.95 | 2.55 | 1.94 |
| 20 | 3.25 | 4.50 | 2.03 |
| **Average** | **3.81** | **3.49** | **9.85** |

*3.2 Results of Users' Satisfaction*

For the satisfaction evaluation, 44 complete questionnaires were analyzed using descriptive statistics. The results indicated that the overall user satisfaction level was very good, with an average score of 4.58, and standard deviation values below 1.0, as presented in Table 13. These results reflect a high level of user satisfaction with the Learning Quality Assurance System (LQAS). Specifically, the average scores for the three evaluated aspects were all above 4.50, highlighting a particularly high level of satisfaction with the quality of information provided. These findings suggest that users perceive the system as highly effective and reliable, particularly in terms of the quality of the information it delivers. This high satisfaction level aligns with user experience studies that emphasize the importance of information quality in influencing overall satisfaction with digital systems. The consistently high scores across different evaluation categories reinforce the system's value in meeting user expectations and needs. Overall, the positive feedback from users not only validates the system's design and functionality but also underscores the importance of continuous improvement to maintain high standards of satisfaction. Future studies could focus on exploring specific aspects of user experience that contribute to satisfaction, aiming to identify potential areas for further enhancement in the system.

**Table 13** The users' satisfaction results

| Issue | Mean | S.D. | Satisfaction |
|---|---|---|---|
| ***Information Quality*** | | | |
| - Information completeness | 4.58 | 0.61 | Very good |
| - Sufficient data for decision making | 4.67 | 0.40 | Very good |
| - Sufficient data for SCGSP analysis | 4.66 | 0.48 | Very good |
| - Accurate reports | 4.52 | 0.45 | Very good |
| - Accurate data compiled based on SCGSP | 4.53 | 0.44 | Very good |
| ***Perceived Ease of Use*** | | | |
| - Easy usage | 4.55 | 0.43 | Very good |
| - Incomplex process for usage | 4.65 | 0.48 | Very good |
| - Good Graphic User Interface (GUI) | 4.54 | 0.49 | Very good |
| - Easy searching | 4.50 | 0.50 | Good |
| - Understanding of data visualization | 4.50 | 0.56 | Good |
| ***Perceived Usefulness*** | | | |
| - Reducing time for searching | 4.63 | 0.57 | Very good |
| - Reducing the time for file preparation | 4.47 | 0.63 | Good |
| - Convenience for SCGSP analysis | 4.56 | 0.51 | Very good |
| - Usefulness for Faculty | 4.65 | 0.53 | Very good |
| Total | 4.58 | 0.50 | Very good |

## 4. Conclusion

This study demonstrates the transformative potential BI systems, supported by a robust ETL workflow, in addressing challenges related to evaluating lecturer qualifications and ensuring compliance with higher education standards in Thailand. The QOX provided a systematic framework for evaluating workflow attributes, achieving high accuracy, completeness, and significant time savings compared to manual processes. High user satisfaction scores further validated the system's effectiveness in terms of information quality, ease of use, and perceived usefulness. The study shows that advanced BI systems with efficient ETL workflows can drastically improve operational efficiency, reduce processing times, and enhance data quality, enabling faster, more informed decision-making. It also highlights the importance of scalability and user-centric design, ensuring adaptability to larger datasets and fostering trust in technology-driven solutions. Methodologically, the QOX framework offers a novel approach to evaluating ETL workflows. Practically the BI system serves as a model for similar institutions. Empirically, the study contributes to the literature on technology adoption in education, encouraging policymakers and leaders to invest in advanced data management technologies to enhance compliance, operational efficiency, and standardization in higher education. Despite its contributions, this study has limitations. Its focus on Thai higher education may limit generalizability, and reliance on user feedback could introduce bias. The study emphasized technical aspects of the ETL workflow and BI system, with less attention to organizational or cultural factors influencing implementation. Additionally, scalability was tested in a controlled environment, leaving real-world performance unvalidated. Future research could expand to diverse educational contexts, conduct longitudinal studies, and explore organizational culture, leadership, and training in BI system adoption. Integrating emerging technologies like AI and machine learning, as well as testing scalability in large-scale, real-world settings, could further enhance the system's applicability and robustness, advancing BI systems in higher education and beyond.

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## 6. References

Arputhamary, B. and Arockiam, L. 2015. Data integration in Big Data environment. Bonfring **International Journal of Data Mining** 5(1): 1-5.

Ashfaq, M., Yun, J., Yu, S. and Loureiro, S.M.C. 2020. I Chatbot: Modeling the determinants of users' satisfaction and continuance intention of AI-powered service agents. **Telematics and Informatics** 54: 101473.

Astriani, W. and Trisminingsih, R. 2016. Extraction, Transformation, and Loading (ETL) module for hotspot spatial data warehouse using geokettle. **Procedia Environmental Sciences** 33: 626-634.

Awad, M.M., Abdullah, M.S. and Ali, A.B.M. 2011. Extending ETL framework using service-oriented architecture. **Procedia Computer Science** 3: 110-114.

Awiti, J., Vaisman, A.A. and Zimányi, E. 2020. Design and implementation of ETL processes using BPMN and relational algebra. **Data & Knowledge Engineering** 129: 101837.

Azeroual, O., Saake, G. and Abuosba, M. 2019. ETL best practices for data quality checks in RIS Databases. **Informatics** 6(10): 1-13.

BiaoJun, L., Yao, C., Zheng, F., Wang, L., Dai, J. and Xiang, Q. 2021. "Intelligent decision support system for business forecasting using artificial intelligence." **Arabian Journal for Science and Engineering** 46(1): 1-11.

Bony, M.N.V., Das, P., Pervin, T., Shak, M.S., Akter, S., Anjum, N., Alam, M., Akter, S. and Rahman, M.K. 2024. Comparative performance analysis of machine learning algorithms for business intelligence: a study on classification and regression models. **Frontline Marketing, Management and Economics Journal** 4(11): 72-92.

Chakraborty, A., Maji, A. and Saha, T. 2021. Transparency in higher education assessment standards: A case study from Thailand. **Higher Education Research & Development** 40(1): 125-140.

Chen, Y. and Lin, Z. 2021. Business intelligence capabilities and firm performance: A study in China. **International Journal of Information Management** 57: 102232.

Cheruku, S.R., Goel, O. and Jain, S. 2024. A Comparative Study of ETL Tools: DataStage vs. Talend. **Journal of Quantum Science and Technology** 1(1): 80.

Cho, H., Chi, C. and Chiu, W. 2020. Understanding sustained usage of health and fitness apps: Incorporating the technology acceptance model with the investment model. **Technology in Society** 63: 101429.

Davis, F.D. 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. **MIS quarterly** 13(3): 319-339.

Dayal, U., Castellanos, M., Simitsis, A. and Wilkinson, K. 2009. Data integration flows for business intelligence, pp. 1-11. *In* **Proceedings of the 12th International Conference on Extending Database Technology: Advances in Database Technology.** Saint Petersburg, Russia.

Gaardboe, R., Nyvang, T. and Sandalgaard, N. 2017. Business intelligence success applied to healthcare information systems. **Procedia Computer Science** 121: 483-490.

Geetha, S., Dhanani, K.R. and Doshi, P.P. 2020. Data analysis and ETL tools in business intelligence. **International Research Journal of Computer Science** 7(5):127-132.

Girsang, A.S., Isa, S.M. and Ginzel, M.E.C. 2020. Implementation of journalist business intelligence in social media monitoring system. **Advances in Science, Technology and Engineering Systems Journal** 5: 1517-1528.

Guan, C., Mou, J. and Jiang, Z. 2020. Artificial intelligence innovation in education: a twenty-year data-driven historical analysis. **International Journal of Innovation Studies** 4(4): 134-147.

Gueddoudj, E.Y. and Chikh, A. 2023. Towards a scalable and efficient ETL. **International Journal of Computing and Digital Systems** 14(1): 10223-10231.

Haenlein, M. and Kaplan, A. 2021. Artificial intelligence and robotics: Shaking up the business world and society at large. **Journal of Business Research** 124(C): 405-407.

Jansawang, N., Insumran, Y. and Kenaphoom, S. 2025. Quality Assurance for Lifelong Education. **A Comprehensive Review. ONESQA Quality Assurance in Education Journal** 1(1): 1-19.

Khan, N., Iqbal, S. and Mahboob, T. 2015. A comparative study of data quality management in data warehouses. **International Journal of Computer and Communication System Engineering** 2: 464-471.

Khatibi, V., Keramati, A. and Shirazi, F. 2020. Deployment of a business intelligence model to evaluate Iranian national higher education. **Social Sciences & Humanities Open** 2(1): 100056.

Khatir, N. and Madani, H. 2024. The impact of digital transformation on achieving outstanding performance in educational administration. **International Journal of Educational Management** 38(7): 1821-1838.

Kleesuwan, S., Mitatha, S., Yupapin, P.P. and Piyatamrong, B. 2010. Business intelligence in Thailand's higher educational resources management. **Procedia-Social and Behavioral Sciences** 2(1): 84-87.

Koivumäki, T., Ristola, A. and Kesti, M. 2008. The effects of information quality of mobile information services on user satisfaction and service acceptance-empirical evidence from

Finland. **Behaviour & Information Technology** 27(5): 375-385.

Liu, D. 2024. October. Business Intelligence Tools for Data Extractions Transformations and Visualizations, pp. 1-4. *In* **2024 International Symposium on Networks, Computers and Communications (ISNCC).** IEEE, Washington DC, USA.

Lucas, A. 2010. Corporate data quality management: From theory to practice, pp. 1-7. *In* **5th Iberian Conference on Information Systems and Technologies.** IEEE, Santiago de Compostela, Spain.

Marshall, L. and De La Harpe, R. 2009. Decision making in the context of business intelligence and data quality. **South African Journal of Information Management** 11(2): 1-15.

Mayuk, V., Falchuk, I. and Muryjas, P. 2021. The comparative analysis of modern ETL tools. **Journal of Computer Sciences Institute** 19: 126-131.

Ministry of Higher Education. 2022. **Higher Education Program Standards B.E. 2022 Title: Science and Research, and Innovation.** Government Gazette vol.135, Special Part 212. (date September 9, 2022). (in Thai)

Moreno, V., Cavazotte, F. and de Souza Carvalho, W. 2020. Business intelligence and analytics as a driver of dynamic and operational capabilities in times of intense macroeconomic turbulence. **The Journal of High Technology Management Research** 31(2): 100389.

Mukul, E. and Büyüközkan, G. 2023. Digital transformation in education: A systematic review of education 4.0. **Technological Forecasting and Social Change** 194: 122664.

Nethravathi, R., Sathyanarayana, P., Vidya Bai, G., Spulbar, C., Suhan, M., Birau, R. and Ejaz, A. 2020. Business intelligence appraisal based on customer behaviour profile by using hobby-based opinion mining in India: a case study. **Economic research-Ekonomska istraživanja** 33(1): 1889-1908.

Niño, H.A.C., Niño, J.P.C. and Ortega, R.M. 2020. Business intelligence governance framework in a university: Universidad de la cost a case study. **International Journal of Information Management** 50: 405-412.

Pikhart, M. 2020. Intelligent information processing for language education: The use of artificial intelligence in language learning apps. **Procedia Computer Science** 176: 1412-1419.

Saebao, S., Matayong, S. and Trakulmaykee, N. 2020. QOX based ETL design for business intelligence system of lecturers' qualifications analysis, pp. 539-542. *In* **2020 17th International Conference on Electrical Engineering/ Electronics, Computer, Telecommunications and Information Technology (ECTI-CON).** IEEE, Phuket, Thailand.

Samir Abdel-Moneim, M., Hamed El-Bastawissy, A. and Hamed Kholief, M. 2015. Quality Driven Approach for Data Integration Systems, pp. 409-420. *In* **Proceedings of the 7th International Conference on Information Technology.** AL-Zaytoonah University, Amman, Jordan.

Simitsis, A., Gupta, C., Wang, S. and Dayal, U. 2010. Partitioning real-time ETL workflows, pp. 159-162. *In* **2010 IEEE 26th International Conference on Data Engineering Workshops (ICDEW 2010).** IEEE, Long Beach, CA, USA.

Simitsis, A., Wilkinson, K., Castellanos, M. and Dayal, U. 2009. QOX-driven ETL design: reducing the cost of ETL consulting engagements, pp. 953-960. *In* **Proceedings of the 2009 ACM SIGMOD International Conference on Management of Data.** MachineryNew YorkNYUnited States.

Souibgui, M., Atigui, F., Zammali, S., Cherfi, S. and Yahia, S.B. 2019. Data quality in ETL process: A preliminary study. **Procedia Computer Science** 159: 676-687.

Susilo, B.W. and Susanto, E. 2024. Employing Artificial Intelligence in Management Information Systems to Improve Business Efficiency.

**Journal of Management and Informatics**, 3(2): 212-229.

Szilveszter, M., Molnár, G. and Nagy, E. 2024. April. Comparison of commercial and open source ETL tools, pp. 000037-000042. *In* **2024 IEEE 11th International Conference on Computational Cybernetics and Cyber-Medical Systems (ICCC).** IEEE, Hanoi, Vietnam.

Theodorou, V., Jovanovic, P., Abellò, A. and Nakuçi, E. 2017. Data generator for evaluating ETL process quality. **Information Systems** 63: 80-100.

Ubachs, G. and Henderikx, P. 2022. Quality assurance systems for digital higher education in Europe, pp. 1-20. *In* **Handbook of Open, Distance and Digital Education.** Springer Nature Singapore, Singapore.

Wand, Y. and Wang, R.Y. 1996. Anchoring data quality dimensions in ontological foundations. **Communications of the ACM** 39(11): 86-95.

Wang, C. and Teo, T.S. 2020. Online service quality and perceived value in mobile government success: An empirical study of mobile police in China. **International Journal of Information Management** 52: 102076.

Wang, G. and Song, J. 2017. The relation of perceived benefits and organizational support to user satisfaction with building information model (BIM). **Computers in Human Behavior** 68: 493-500.

Wang, J. and Liu, B. 2020. Design of ETL tool for structured data based on data warehouse, pp. 1-5, *In* **Proceedings of the 4th International Conference on Computer Science and Application Engineering.** ACM, New York, United States.

Wang, N. 2023. Design of an intelligent processing system for business data analysis based on improved clustering algorithm. **Procedia Computer Science** 228: 1215-1224.

Wang, Y. 2021. Educational management system of colleges and universities based on embedded system and artificial intelligence. **Microprocessors and Microsystems** 82: 103884.

Xu, F. and Du, J.T. 2019. Examining differences and similarities between graduate and undergraduate students' user satisfaction with digital libraries. **The Journal of Academic Librarianship** 45(6): 102072.

Zineb, L. and Rachid, F. 2023. November. ETL Technologies for Big Data: A Comparative Study, pp. 1-6. *In* **2023 IEEE International Conference on Advances in Data-Driven Analytics And Intelligent Systems (ADACIS).** IEEE, Marrakesh, Morocco.