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# Web-based Application for Cancerous Object Segmentation in Ultrasound Images Using Active Contour Method

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## Abstract

*Segmentation, or the process of separating clinical objects from surrounding tissue in medical images, is an important step in the Computer-Aided Diagnosis (CAD) system. The CAD system is developed to assist radiologists in diagnosing cancer malignancy, which in this research is found in ultrasound (US) medical imaging. The manual segmentation process, which cannot be accessed remotely, is a limitation of the CAD system because cancer objects are screened frequently, continuously, and at all times. Therefore, this research aims to build a user-friendly web application called COSION (Cancerous Object Segmentation) that provides easy access for radiologists to segment cancer objects in US images by adopting an active contour method called HERBAC (Hybrid Edge & Region-Based Active Contour). The waterfall method was used to develop the web application with Django as the web framework. The successfully built web application is named Cosion. Cosion was tested on 114 radiology breast and thyroid US images. Functional, portability, efficiency, reliability, expert validation, and usability testing concluded that Cosion runs well and is suitable for use with a functionality value of 0.9375, an average GTmetrix score of 96.43±0.66%, 100% stress testing percentage, 77.5% expert validation, and 74.45% usability. These quantitative performances indicate that the COSION web application is suitable for implementation in the CAD system for US medical imaging.*

**Keywords:** active contour, cancer, ultrasonography, segmentation, website

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## Introduction

The stages in a CAD (Computer Aided Diagnosis) system are preprocessing, segmentation, feature extraction, and classification (Nugroho, Hidayat, Adi Nugroho, et al. 2020). Segmentation plays a crucial role in CAD systems (Noble 2010), as it is used to separate clinical objects from surrounding tissues in medical images. The segmentation stage is critical because it provides objective data such as geometric information, shape, edge boundaries, and textures that are useful for subsequent steps, such as feature extraction and classification, to obtain accurate diagnostic results (Nugroho et al. 2019).

CAD systems are developed to assist radiologists in diagnosing cancer malignancy, specifically in this research, using medical imaging techniques such as ultrasonography (US). The US is used as a screening tool for suspicious objects such as breast lesions and thyroid nodules in cancer diseases (Nugroho et al. 2021a). CAD systems are used as a second opinion by radiologists due to the subjective nature of ultrasound (US) readings, which leads to high variability in the diagnostic process (Rodríguez-Cristerna et al. 2017) caused by the poor quality of US images (Munarto et al. 2018). Cancer-related mortality rates in Indonesia are indeed quite high. According to Globocan 2020 data, the prevalence of cancer deaths in Indonesia over the past 5 years reached 946,088 cases (Globocan 2020).


(a) (b) (c)

**Figure 1. Ultrasound: S Detect for Thyroid RS80 (a) RS80 Machine, (b) segmentation manually, (c) segmentation results (Source: https://youtu.be/Syu4NjD2qwA)**

CAD has been widely developed in several US machines, including the Ultrasound: S Detect for Thyroid RS80 developed by Samsung Medical Imaging as shown in Figure 1 point a (Samsung 2016). The RS80 is not only used to detect thyroid cancer objects but also breast lesions (Electrónica Y Medicina SA 2015).

However, the machine still has a weakness in the segmentation stage. In this stage, to perform segmentation, radiologists still need to manually initialize the location of the cancer object as seen in Figure 1 point b, and need to select the desired segmentation results as shown in Figure 1 point c. In addition, the RS80 machine is not supported with easy access that allows radiologists to diagnose stored data (repository) without direct contact with the ultrasound machine. The era of big data allows for storing many ultrasound images that accumulate due to many routine patient check-ups each day. The advanced technology of the US needs to be accompanied by ease of access for radiologists and clinical operators.

The manual segmentation process, which cannot be accessed remotely, poses a limitation for CAD systems. This is because screening for cancer objects is a repetitive and continuous task that needs to be performed frequently. If done manually, it would be ineffective and prone to human errors due to the exhaustive nature of the work.

To enhance the effectiveness of CAD systems in medical imaging diagnosis, several research studies have been conducted. However, these studies have mainly focused on developing the formulation methods rather than implementing them in a user-friendly interface that can be directly used by medical professionals.

Almajalid et al. (2018) developed a segmentation method based on the U-Net deep learning architecture for breast ultrasound imaging to improve the accuracy of diagnosis in a CAD system (Almajalid et al. 2018). The research findings demonstrated that the modified U-Net method was more robust and accurate in segmenting breast lesions in ultrasound images, outperforming the other two methods significantly with a Dice coefficient (DC) of 0.825 and a similarity level of 0.698.

Nugroho et al. (2020) conducted a study by developing a method called combinatorial active contour bilateral filter (Nugroho, Hidayat, Adi Nugroho, et al. 2020). The research presented a combined framework for ultrasound image segmentation using a bilateral filter (BF) and Region-Edge-based AC model. The research findings showed a Dice coefficient value of 90.05 ± 5.81% using a dataset consisting of 258 ultrasound images with corresponding ground truth.

The research conducted by Pathan et al. (2022) implemented an artificial intelligence-based method for rapid breast cancer detection in ultrasound images into a web application (Pathan et al. 2022). The research findings demonstrated that the proposed framework was effective, achieving a test accuracy of 81.02%. Therefore, it can be used in CAD systems to reduce human errors in determining diagnostic outcomes.

In 2023, Nugroho 2023 developed a web application that adopts the method called MoRbAC (Morphological Region-Based Active Contour) for automatically detecting cancer objects in ultrasound images (Nugroho et al. 2023). MoRbAC is a combinatorial framework consisting of a simplified Chan-Vese (CV) active contour model and morphological image operations. The simplified CV serves to segment the objects, while the morphological operations play a role in reducing detection errors and localizing them specifically (Nugroho 2022). The proposed web-based application has been validated on 20 breast lesion and thyroid nodule ultrasound images. Python programming with the Flask framework was used to deploy this application. The validated results are compatible with various browsers and achieve an average accuracy of 98.75%. This achievement demonstrates that MoRbAC is suitable for use as an ultrasound CAD detection technique in a web service system.

Based on the literature, most CAD developments primarily consist of formal models and program algorithms. The development of CAD systems aimed at practical usability, such as web-based CAD, especially focusing on the segmentation stage, is still relatively limited. So, how can we build an application that provides easy access for radiologists to segment cancer objects in ultrasound images within an automated CAD system?

This research aims to address that question by developing a web-based application for CAD that adopts the active contour (AC) method (Nugroho et al. 2021b). The AC method has the potential for automated segmentation. A web-based application was chosen due to its various advantages, such as accessibility at any time and from anywhere if the device is connected to the internet. This allows radiologists to perform segmentation processes more efficiently and in a user-friendly manner.

In this research, the developer will adopt the AC method to be implemented in a web application that can be used by medical professionals to perform cancer object segmentation on ultrasound images. The web application is expected to contribute to the creation of a more modern technology that can be utilized as a supportive system in the process of effectively and efficiently diagnosing cancer malignancy in ultrasound images. Modern health technology has the potential to bring about various advantages, including cost reduction in healthcare and prevention of potential health issues (Chrisdianti et al. 2023).

In addition, by developing web applications in this study, radiologists also gain benefits such as implementing a segmentation process that is more flexible and easier to perform with accurate segmentation results from the object being investigated.

The structure of this paper is as follows: after explaining the background, research gaps, and study objectives in the Introduction, a review and theory used in Literature Reviews. Next, the development of the web application will be discussed in the Methodology. Results and Discussion will explain the research findings, including the various predetermined testing schemes. Lastly, the Conclusion will summarize the research findings and provide recommendations for further studies.

## Literature Reviews

### *Similar Studies*

Segmentation is an effort to partition an image into desired regions through the separation of information required from data for further purposes or objectives (Chen et al. 2019). There have been

many segmentation techniques developed by previous researchers in medical image processing. A study by de Paula et al. in 2016 developed a Java-based web application to segment 150 Cardiac MRI images using the AC Snakes method in less than 5 seconds (de Paula et al. 2010). Arslan Tuncer's research in 2019 developed an Android-based program using a hybrid method (template matching and AC) for segmenting the Optic Disc (Arslan Tuncer 2019). The research found the mean value of the dice coefficient (DC) to be 0.943, accuracy of 0.90, specificity of 0.961, and sensitivity of 0.931. Syaputri's research in 2019 also used AC Snakes to segment human lung thorax X-ray images with a result of MSE (Mean Squared Error) value of 0.00013733 (Syaputri 2019). The study by Vasconcelos et al. in 2019 utilized the AC method named MGAC (morphological geodesic active contour segmentation) to automatically segment skin lesions (Vasconcelos et al. 2019). The results showed Jaccard index (86.16%), DC (92.09%), Matthew's correlation coefficient (87.52%), sensitivity (91.72%), specificity (97.99%), accuracy (94.59%), and F-measure (93.82%). The research conducted by Albahli et al. in 2020 used AC for melanoma lesion segmentation combined with morphological operations and a YOLOv4 object detector (Albahli et al. 2020). The result of the study showed an average dice score of 1 and a Jaccard coefficient of 0.989. The research by Babu et al. in 2021 utilized level set and Chan-Vese (CV) techniques for brain cancer segmentation using MRI (Babu et al. 2021). The results obtained showed a DC value of 97.80, a Hausdorff distance (HD) of 1.86, and a Jaccard similarity index (JSI) of 97.04.

### *Active Contour (AC)*

The effectiveness of the AC method is demonstrated by several studies above, the AC method is chosen in this study to perform the segmentation of cancer objects on ultrasound images and implemented in a web-based application. Active contour (AC) is a model that is highly effective in medical image processing, as it can separate the necessary pixels from the foreground (Kass et al. 1988). The main application of AC in image processing is to define smooth shapes in the image and form a closed contour for the region. The AC method is divided into three (3) models, local edge-based, region-based, and hybrid model.

Local edge-based methods like GAC (Geodesic Active Contour) (Caselles et al. 1997) are capable of performing specific object segmentation but lack detection capabilities. On the other hand, global region-based methods like CV (Chan-Vese) (Chan and Vese 2001) can perform segmentation on the entire image but lack specificity. Therefore, there is a need for an automated method that combines the strengths of both approaches and transitions seamlessly between global and local segmentation. In this research, the HERBAC (Hybrid Edge and Region-Based Active Contour) model (Nugroho et al. 2021b) is adopted and implemented in a web application.

### *HERBAC Method*

The HERBAC (Hybrid Edge and Region-based Active Contour) method combines the CV model for global segmentation and GAC for accurate local segmentation. This automated method is applied for object detection to generate initial contour estimates using the simplified formulation of CV (Nugroho et al. 2021b). To achieve automatic detection of cancerous objects, the CV formulation has been simplified in a previous study (Nugroho 2022). The simplified regularized CV model, followed by morphological operations, is utilized for detecting cancerous objects in ultrasound images. The proposed method demonstrates relatively high performance, with an average IoU score of 84.20% obtained from validation tests using 20 thyroid and breast ultrasound images.

The HERBAC method was chosen because it has been tested for segmenting 114 breast and thyroid radiology ultrasound images, achieving a high accuracy of 92.31%. These results demonstrate the effectiveness and efficiency of the proposed method, indicating its potential for practical implementation in CAD systems for radiology ultrasound imaging.

## Methodology

Several methods for developing web applications have been created, such as waterfall, agile, rapid prototyping, spiral, incremental, and others. However, in this research, the waterfall method was chosen as the approach for developing the web application. The stages of development are shown in Figure 2.

The waterfall method was chosen over other methods in this research because of its sequential and non-overlapping stages, which progress from top to bottom (Balaji and Murugaiyan 2012). Each stage has a designated timeframe and is completed before moving on to the next stage. This methodology enables effective project deadline management. Additionally, the waterfall model allows for the identification and resolution of design flaws in the system before final product development, as the requirements are well-defined before the commencement of development. Compared to other models like agile, which is developed iteratively to accommodate changes in a project, the waterfall model is more suitable for well-conceptualized projects that do not require continuous changes, as in this research. Additionally, the waterfall model has been used by several studies in developing web applications (Alsagaby and Alharbi 2021; Maulana et al. 2021).

The research was conducted at the E6 Building Research Laboratory, Faculty of Engineering, UNNES. It involved the construction of the HERBAC method algorithm programming using the Python programming language, which took approximately eight months (from March to October 2022). This was followed by the development of a Python-based web application using the Django framework, which served as the intermediary for user interaction with the application for a period of four months (from November 2022 to February 2023).

The tools used in designing the web application in this research include hardware specifications of a desktop computer with an Intel (R) Core (TM) i7-2600 CPU @ 3.40GHz processor, 4.00 GB of RAM, and an OS of Windows 7 64-bit. The software used includes the Python programming language, Spyder (Text Editor), Visual Studio Code (Text Editor), and Google Chrome (browser). Additionally, the materials used in this study include a dataset of 114 thyroid and breast cancer images obtained from the Department of Radiology, RSUP Dr. Sardjito and Dr. S. Hardjolukito, The Air Force Central Hospital in Yogyakarta (Nugroho et al. 2021b; Nugroho, Hidayat, Nugroho, et al. 2020).

This research involved several parties, including radiologists as experts to test the developed web application, practitioners knowledgeable in the HERBAC method to test the algorithm's suitability on the web, and common people as direct users to evaluate the effectiveness of the web application before it was tested by experts.

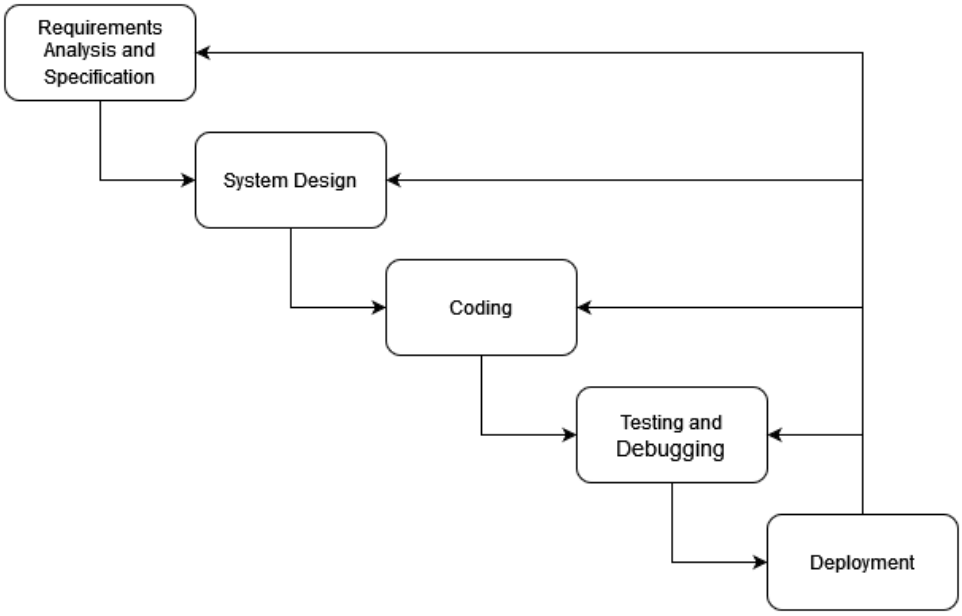



**Figure 2. Waterfall development method (Source: Balaji and Murugaiyan 2012)**

The analysis and requirements specification phase aims to determine the resources needed for the development of the web application, including functional and non-functional requirements. In line with the research objectives, the developed web application is intended to be user-friendly, easily accessible, and assist radiologists in diagnosing cancer malignancy by effectively implementing the adopted HERBAC algorithm. Therefore, the web application is designed to be simple and easily understandable, even for common people. Based on this and consultations with experts, the developer analyzed the functional and non-functional requirements of the web application, as shown in the following Table 1. Web design is used for preparation before implementation by writing code to facilitate web development based on the results of the analysis conducted.

Next, the coding stage follows. This stage involves implementing the HERBAC algorithm into a code program. The HERBAC algorithm is implemented in the Python programming language. Python is an easy-to-use and open-source programming language (Vallat 2018). Python also has many advanced libraries such as OpenCV and Scikit-Image for image processing, Numpy for scientific calculations, and Django as a web framework. These four libraries are the main libraries used in this research to develop the web application. The coding process then continues with the creation of the user interface. This step is divided into two parts, coding for the backend and frontend. The backend is done by calling the functions that have been created in the previous step to be displayed in the browser using the Django framework. Next, the front-end stage is done to create templates using HTML and CSS languages according to the designed user interface.

The next step is testing. The web application will be tested using several criteria in the ISO 25010 model, which include functionality aspect using black box testing, portability by simulating web usage on various devices, efficiency using GTmetrix tools, reliability using WAPT tools, as well as expert validation and usability testing using a questionnaire to experts.

1. The functionality testing is conducted to check whether the web application complies with the intended specifications and functional requirements created in the requirements analysis. This testing uses the black box testing method. Black box testing is a testing method that focuses on the functional specification of software with testers defining a set of input conditions and testing the functional specification of the program (Hidayat and Muttaqin 2018). After the functionality testing, the results will be obtained in the form of the number of valid and invalid functions. To analyze the data, standard interpretations specified in ISO/IEC TR 9126-2:2002 will be used (Nalarita and Listiawan 2018). The formula for data analysis used is shown in Equation 1.

$$X = 1 - \frac{A}{B} \qquad \text{Equation (1)}$$

Where:

X = Functionality value
A = Total number of invalid functions
B = Total number of functions

2. Portability testing is performed by simulating the use of the web on various devices connected to the internet through a browser. In this study, portability testing is limited to desktop devices running Windows and Mac OS, as well as mobile devices running Android and iOS with browsers including Internet Explorer, Microsoft Edge, Mozilla Firefox, Opera, Google Chrome, Safari, Android browser, and iPhone.
3. The efficiency testing is conducted to measure the web performance using the basic parameters recommended by Google Developer for Page Speed and presented by Yahoo Developer Network through the GTmetrix website by entering the website address for each web page at https://GTmetrix.com/. In the efficiency testing, two values are obtained, which are the performance score and the structure score, and both scores are used to get the GTmetrix Grade. The GTmetrix Grade value is obtained from Equation 2 (GTmetrix 2020).

$$GTmetrix\ Grade = (0.7 \times Performance) + (0.3 \times Structure) \qquad \text{Equation (2)}$$

**Table 1. Requirements Analysis and Specification**

| Functional requirements | Non-functional requirements |
|---|---|
| the web application is built with the Django framework, which uses the Python programming language | the web can be accessed anytime, anywhere, as long as there is an internet connection |
| the web has a navigation bar displayed on every available page with Home, Segmentation, and About menus | the web operates fully online 24 hours a day. |
| the web starts by displaying the Homepage which also includes a Segmentation menu | the web application can be run on various platforms |
| user uploads US image on segmentation page to start segmentation process. Uploading input images is limited to bmp or png image formats (in this study it is limited by the png format according to the available dataset) | the security of the web application and stored data is ensured |
| after the US image is uploaded, the web performs a segmentation process using the HERBAC method | |
| the web displays output in the form of three images: the first image is the input image, the second is the detected image, and the third is the segmented image using the HERBAC method, and there is an information section to find out the name of the uploaded image, area, etc. | |
| users can see the segmentation process after the output is displayed with a button called process which is displayed in gif format | |
| users can delete input and output images by clicking the Delete button, which then redirects the user to the Segmentation page | |
| users can carry out the segmentation process again by re-uploading the desired ultrasound image | |
| users can find information about the development of the segmentation method used on the about page by clicking on the navbar | |

4. Reliability testing is done by putting a certain load on the web to determine whether the web can run well or not. In this study, reliability testing used the WAPT (Web Application Load, Stress, and Performance Testing) software tool that will perform stress testing through active user simulation to obtain the percentage of success in terms of sessions, pages, and hits (Ma'arief et al. 2019). The results of stress testing must meet Telcordia standards, which are at least 95% (Asthana and Olivieri 2009).
5. The next step is expert validation testing. This test is carried out to validate the suitability of the HERBAC algorithm in the web application with experts using a questionnaire method. The experts are the main authors of the HERBAC algorithm in the reference article entitled "Development of Active Contour Model for Radiological Ultrasound Image Segmentation" (Nugroho et al. 2021b). The data analysis technique used to measure the feasibility of the web application in the expert validation test is the percentage formula of application feasibility according to (Sugiyono 2015) as shown in Equation 3.

$$P = \frac{\sum n}{\sum N} \times 100\%$$

Equation (3)

Where:

$P$ = Application feasibility percentage
$\sum n$ = Total score of the evaluation aspects by the experts
$\sum N$ = The maximum score of the assessment

6. Usability testing is used to determine the feasibility of a web application. This usability testing uses a questionnaire method for radiologists. From each questionnaire result, data will be processed into a conclusion of whether the built application is feasible or not. There are five indicators in determining the questionnaire questions in usability testing. Learnability which is related to the user's ease of operating the web application. Efficiency which explains the user's speed level in using and learning the web application. Satisfaction which explains the user's satisfaction level in using the web application. The error explains that the web application is consistent when used by users so that it does not experience problems. Memorability is the ability to remember and the user's ease without having to learn again after not using it for a long time (Setiawan and Widyanto 2018). The data analysis technique used to measure the feasibility of the web application in usability testing is to use the formula in Equation 3.

At the final stage of the waterfall method, which is the deployment phase, the application that has passed the tests is distributed to the users. In this phase, deployment is done by hosting the website to publish it so that users can access it on the internet.

## Results and Discussion

The result of this study is the development of a web application named Cosion (Cancerous Object Segmentation) using the waterfall model. Cosion can be accessed through http://cosion.my.id/. Cosion is responsive, as shown in Figure 3, and has three main pages, Home, Segmentation, and About. The Home page contains brief information about Cosion, and there is a Segmentation menu that users can select to perform the segmentation process as shown in Figure 4. Furthermore, the Segmentation page starts with an Upload file page as shown in Figure 5, where users can upload a US image. This is followed by displaying the result as shown in Figure 6 if the segmentation process has been completed, which contains the input and output images of the segmentation result. The About page, as shown in Figure 7, contains information about Cosion, along with menus that users can select for further information about the segmentation method used. In addition, there is also information about the libraries used in web development packaged in the library logo image.

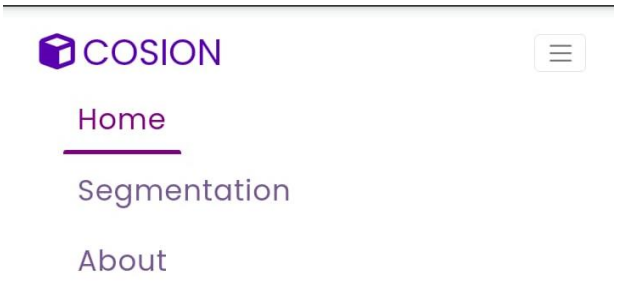



**Figure 3. Responsive mode display with menu bars**

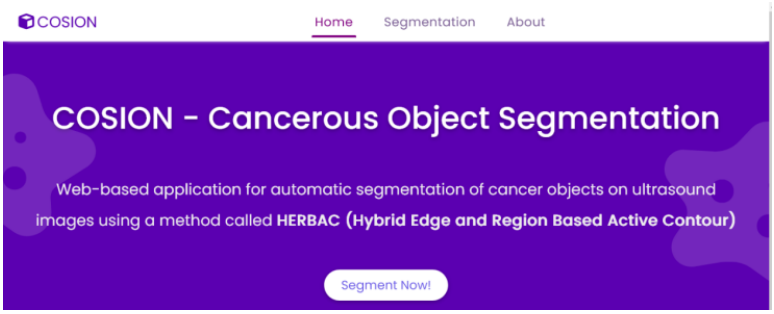



**Figure 4. View of the Cosion home page**

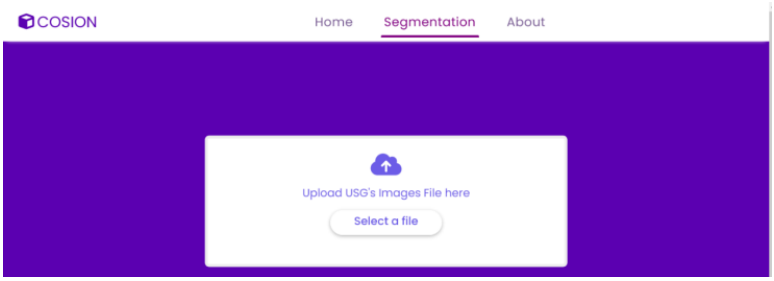



**Figure 5. Display of Cosion file upload page**

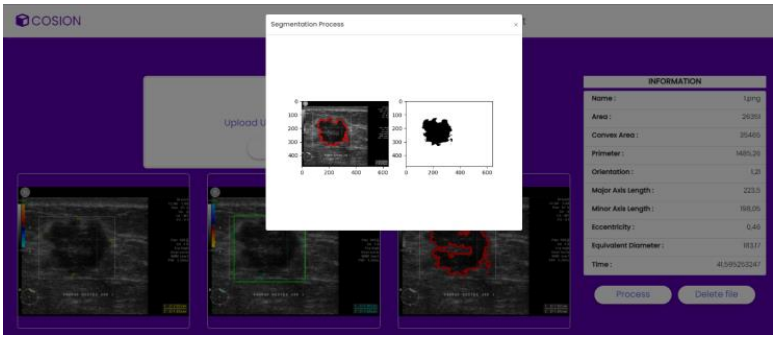



**Figure 6. Display results on the Cosion segmentation page**

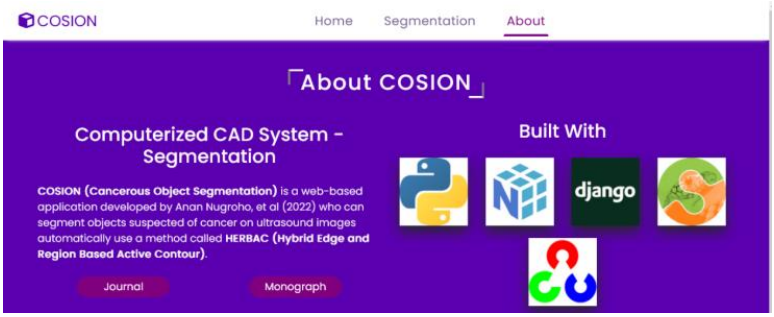



**Figure 7. About Cosion page display**

Cosion has been tested on 114 confirmed breast and thyroid cancer ultrasound image datasets, with six aspects assessed: functionality, portability, efficiency, reliability, expert method validation, and usability.

## *Functionality Testing*

The testing of Cosion on the aspect of functionality using black box testing resulted in the web application being rated as good. The tested features include the menu on the navbar, the home page,

segmentation features that encompass the upload process and segmentation until generating the output, as well as the features on the About page.

Each feature within Cosion can function properly as expected. This is evidenced by the X value generated which is close to 1, specifically 0.9375 as shown in Table 2. A good functionality value is achieved if X approaches 1 according to ISO/IEC TR 9126-2:2002 measurement standards, which is $0 \leq X \leq 1$.

**Table 2. Functionality Testing Result using Blackbox**

| Respondents | Total Invalid function | Total function | Functionality Value | Category |
|---|---|---|---|---|
| Media Expert | 1 | 16 | $X = 1 - \frac{A}{B} = 1 - \frac{1}{16} = 0,9375$ | Good |

### *Portability Testing*

According to the results of the portability testing as shown in Table 3, the Cosion web application that was built can be accessed well on various browsers in different OS and devices, both on desktop and mobile if there is an internet connection, except an error when displaying the menu bars in responsive mode on the Safari browser. However, this error does not affect the segmentation process. The segmentation results are still displayed properly and can be accessed through alternative menus available on each page.

**Table 3. Portability Testing Result**

| No. | Device | OS | Browser | Version | Result |
|---|---|---|---|---|---|
| 1. | Desktop | Windows | Microsoft Edge | 109.0.1518.78 | Success, without error |
| | | | Mozilla Firefox | 109.0.1 | Success, without error |
| | | | Google Chrome | 109.0.5414.120 | Success, without error |
| | | | Opera | 95.0.4635.37 | Success, without error |
| | | Mac OS | Safari | 13.2.1 | Success, with an error |
| 2. | Mobile | Android | Browser Android | V13.22.1-gn | Success, without error |
| | | iOS | Browser iPhone | 14.0.1 | Success, without error |

### *Efficiency Testing*

The efficiency testing results using GTmetrix by testing all pages on the Cosion web application revealed that it was rated as good and can be further developed, as shown in Table 4 which categorizes Cosion as Grade A with a score of 96.43±0.66% and an average time required to load a page on Cosion of 1.8±0.36 seconds.

**Table 4. Efficiency Testing Result using GTmetrix**

| Page | Performance (%) | Structure (%) | Grade (%) | Time (s) |
|---|---|---|---|---|
| Home | 97 | 92 | 95.5 | 2.3 |
| Segmentation | 99 | 92 | 96.9 | 1.5 |
| About | 99 | 92 | 96.9 | 1.6 |
| **Average** | **98.3** | **92** | **96.43** | **1.8** |

### *Reliability Testing*

The reliability testing results using WAPT to find the percentage of success in terms of sessions, pages, and hits with stress testing simulation shown in Table 5. Both prove that Cosion web application can perform well when given a load according to the scenario, which is a load of 20 active users within 5

minutes, with 2 users logging in every 10 seconds. The stress testing percentage obtained is 100%. This result has met the Telcordia standard, which is a minimum of 95%.

**Table 5. Reliability Testing Result using WAPT**

| Profile Name | Successful sessions | Failed sessions | Successful pages | Failed pages | Successful hits | Failed hits |
|---|---|---|---|---|---|---|
| Cosion20user | 183 | 0 | 1959 | 0 | 6935 | 0 |
| Session success rate = 100% | Session pages rate = 100% | | Session hits rate = 100% | | | |

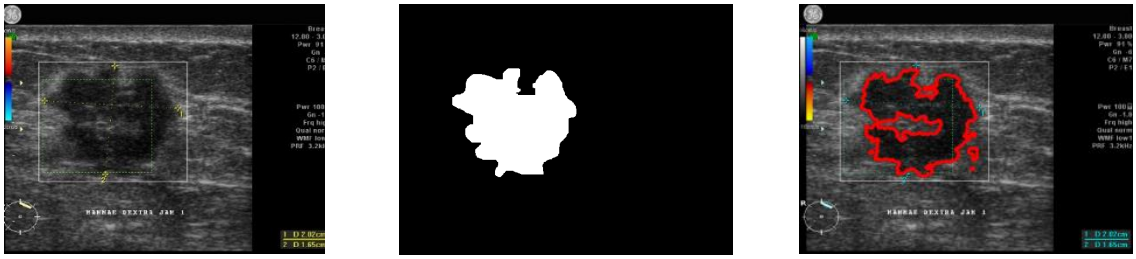
### *Experts Method Validation and Usability Testing*

Questionnaire testing was conducted with experts in both the HERBAC method validation and usability testing. Both tests used a Likert scale of 1 to 4. A value of 1 means Not Suitable or Poor, 2 means Less Suitable or Not Good, 3 indicates Suitable or Good, and 4 means Highly Suitable or Very Good. The results were then processed using Equation 3 and will be categorized as Not Suitable, Less Suitable, Suitable, or Highly Suitable. The test instruments for expert validation testing of the HERBAC method are shown in Table 6.

**Table 6. Method expert validation test instrument**

| No. | Indicator |
|---|---|
| 1. | Appropriateness of program results compared to results in the previous study |
| 2. | The functional suitability of the adopted HERBAC method |
| 3. | The workflow of the running HERBAC algorithm |
| 4. | The speed of the segmentation process in the program |
| 5. | Developed web practicality |
| 6. | Program consistency in segmenting cancer objects on US images |

To answer the questionnaire, the confusion matrix method was used to determine the conformity of the segmentation results with the ground truth provided by the doctors. Both results overlapped to determine the areas of TP (True Positive), TN (True Negative), FP (False Positive), and FN (False Negative). The comparison between the ground truth and the segmentation results using HERBAC is illustrated in Figure 8.



(a) (b) (c)

**Figure 8. The results of the HERBAC method program with (a) input, (b) ground truth, and (c) Cosion**

The validation testing of the HERBAC method to determine the accuracy of the HERBAC method in the Cosion web application obtained a percentage of 77.5%. This result proves that all features in the HERBAC method have been adopted in the Cosion web application, and the HERBAC workflow has been executed the same in the web application.

According to Table 7, the usability testing using a questionnaire aimed at medical experts, specifically three specialist doctors, resulted in a percentage of 75.8%. The questionnaire consisted of 16 questions divided into 5 indicators, including Learnability (5 questions with a maximum score of 20), Efficiency (3 questions with a maximum score of 12), Satisfaction (5 questions with a maximum score of 20),

Error (2 questions with a maximum score of 8), and Memorability (1 question with a maximum score of 4). Both percentages indicate that the Cosion web application is suitable for use by radiologists in assisting the cancer malignancy diagnosis process in the segmentation stage.

**Table 7. Usability Testing Result**

| Respondent | Learnability | Efficiency | Satisfaction | Error | Memorability |
|---|---|---|---|---|---|
| Respondent 1 | 15 | 10 | 15 | 6 | 3 |
| Respondent 2 | 15 | 9 | 15 | 6 | 3 |
| Respondent 3 | 17 | 7 | 15 | 4 | 3 |
| Total | 47 | 26 | 45 | 16 | 9 |
| $P = \frac{\sum n}{\sum N} \times 100\% = \frac{143}{192} \times 100\% = 74,45\%$ | | | | | |

## *Discussion*

This research developed a computerized CAD system based on a website to assist radiologists in segmenting suspected cancer objects during the cancer malignancy diagnosis process. To perform the segmentation process, this research adopted an active contour method called HERBAC. To assess the suitability of the HERBAC algorithm implemented in the Cosion web application, a validation test was conducted with the method's creator. The test resulted in a percentage of 77.5%, indicating that Cosion is deemed suitable for adopting the HERBAC algorithm.

The Cosion web application is considered good according to testing on the functionality aspect using black box testing with an X value of 0.9375. Each feature in the Cosion web application can function properly as expected. The Cosion web application can be accessed well in various browsers on various operating systems and devices, both desktop and mobile if there is an internet connection. All pages in the Cosion web application are rated good and can be developed according to the efficiency testing results using GTmetrix with a score of 96.43±0.66% in the Grade A category and an average load time of 1.8±0.36 seconds per page. The Cosion web application can run well in terms of reliability with stress testing simulations and meets Telcordia standards when given a load according to the scenario, which is a load of 20 active users for 5 minutes with 2 users entering every 10 seconds. The stress testing percentage obtained was 100%. In usability testing, Cosion was tested on radiologists with a resulting percentage of 74.45%.

Based on the usability testing results, Cosion can be considered learnable. It was deemed relatively easy to understand and the presented information and content were clear and specific. In terms of efficiency, the results indicate that Cosion is not yet able to perform segmentation quickly. However, all respondents agreed that Cosion can speed up the diagnosis process. Additionally, Cosion has proven to offer a CAD system that can assist medical professionals in diagnosing cancer malignancies. It is also capable of accurately segmenting suspected cancer objects.

The features in Cosion performed well during testing. However, there were occasional errors due to unstable internet connections. The security aspect of Cosion was also considered weak in terms of accommodating patient data. The testing results for various aspects suggest that Cosion is worthy of implementation. However, further development is needed, such as conducting tests on datasets with noisy ultrasound images. Additionally, there is feedback to improve Cosion's compatibility with slower networks.

Unlike traditional CAD systems that require large machines, this web-based application can be accessed anywhere and anytime through a web browser on devices connected to the internet. Additionally, this web application allows for segmentation processes on a data repository, enabling remote diagnosis to be conducted.

Research on developing CAD systems with easy access, such as web-based systems, has not been extensively conducted. The study by (de Paula et al. 2010) developed a Java-based web application implemented for segmenting 50 Cardiac MRI images using the AC Snakes method in less than 5 seconds. In the research by (Pathan et al. 2022), an artificial intelligence-based method was used for rapid breast cancer detection in ultrasound images, achieving an accuracy of 81.02%. (Arslan Tuncer 2019) developed an Android-based program using a hybrid method (template matching and AC) for segmenting the Optic Disc, resulting in an accuracy of 0.90. Additionally, there is also a study by (Nugroho et al. 2023) that used the AC method called MoRbAC to develop a web application as part of a computer-aided design system. However, the web application focused on the detection stage, producing initial contours with an accuracy of 98.75%.

Apart from the differences in the objects being studied, several applications developed in these studies have not been directly tested on experts, so their implications in the medical field are not yet known. The testing conducted mainly focused on the system's reliability in performing its tasks based on the methods used.

In this study, the segmentation method used is a method previously developed (HERBAC) that has been tested for accuracy and achieved a high value of 92.31%. Therefore, the testing in this research focuses more on the reliability of the developed web application, following the testing criteria of ISO 25010 software and incorporating validation aspects by the method expert (the creator of the HERBAC method), with a validation result of 77.5%.

### *Implications*

The development of the Cosion web application has led to the creation of technological advancements in healthcare, particularly in CAD systems for cancer malignancy diagnosis. Cosion can assist healthcare professionals in performing segmentation processes more efficiently and accurately by avoiding human intervention, thus minimizing human errors. With the AC method called HERBAC adopted in Cosion, the segmentation process can run automatically. As a result, medical experts can perform their work more flexibly without being bound by time and location. By providing only a device connected to the internet, the segmentation process can be carried out. The user-friendly and easily accessible nature of the Cosion application is expected to help medical professionals speed up the process of cancer malignancy diagnosis, leading to faster patient management.

## Conclusion

Based on the results of designing, building, and testing the Cosion web application for segmenting cancer objects on US images using the HERBAC method previously described, it can be concluded that the Cosion web application built in the context of developing a CAD system can be used to segment breast and thyroid cancer objects automatically. Cosion is deemed suitable for adopting all algorithms in the HERBAC method. This is supported by web testing conducted on five other aspects: functionality, portability, efficiency, reliability, and usability. The Cosion web application has demonstrated good performance in these aspects. Through usability testing, it has been determined that Cosion is capable of efficiently and user-friendly assisting radiologists in performing object segmentation of cancerous tissue in ultrasound images.

However, Cosion has several limitations. The main limitation is that it can only be used when connected to the internet. Therefore, in areas with limited internet access, Cosion cannot be utilized. Further development, such as creating an Android or desktop-based application, is required to address this issue. Additionally, Cosion has only been tested on datasets that confirmed thyroid and breast cancer cases. Further research is needed to evaluate the effectiveness of Cosion in segmenting cancerous objects in non-specific ultrasound images. Furthermore, Cosion is limited to the segmentation stage of the CAD system. It cannot provide a definitive conclusion on the malignancy of detected cancer objects. Cosion only assists radiologists in speeding up the diagnosis process by automatically performing object segmentation.

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# The Influence of Information Types and Search Intention in Using Branded or Generic Search Query

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## Abstract

*This study aims to analyze the effect of each type of information and search intention on the use of branded or generic search queries on search engines. This is done because of the emergence of the phenomenon of information overload or explosion of information. The types of tourism information studied are transportation, accommodation, restaurants, shopping places, and tourist attractions with two types of intention, namely purchase intention and intention to search. This study used a quantitative approach by distributing online questionnaires to users who had searched using a search engine and managed to collect 1,256 respondents. Data were analyzed using binary logistic regression. We found that intention influences the use of branded or generic search queries and several types of information influence the use of search queries. Transportation and shopping information could influence users in choosing to use generic or branded search queries.*

**Keywords:** purchase intention, intention to search, search engine, e-tourism, generic search query, branded search query, keyword

## Introduction

Along with the development of the internet, the emergence of e-commerce in the community changed many things in the business world. E-commerce is applied in many fields of business, one of which is tourism. The world of tourism has become one of the largest and fastest growing economic sectors in the world. The increasing number of Indonesia's tourism is deemed to be potential, and the tourism

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stakeholders would like to change its behavior because the innovation cycle is getting shorter and faster. Today, all aspects of life are always connected to digital.

The traveler journey start at the experience stage. At this stage, the public shares their travel experience through engagement using social media. Furthermore, people who see the stories would dream to travel because of the digital marketing campaign. The pre-arrival stage is the step where people start planning through web portals and mobile apps information. Then, it will continue by making reservations through the facilities of web booking portal or mobile booking apps. Afterwards, during trips activities, traveler will feel the experience in enjoying the facilities. Traveler journey then back again at the stage of experience. This cycle would systematically form new information and stories every time.

Today, the amount of information available on the internet has reached enormous volumes that can inflict disorientation to users and make it difficult for them to assimilate and analyze it. Nowadays, tourism-related information services such as transportation, restaurant menus, accommodation locations and rates, and other service is available on the internet. Thus, the tourism sector has now been fully converted into a digital world (Montejo-Ráez et al. 2011).

Online search is already inherent to people's habits of seeking information, especially when users want to find out the information about a brand. This can satisfy the public's curiosity about the brand and can influence their decision (Cheng et al. 2017). Search engines are the main gateways of the public to seek information on the internet (Ayanso and Karimi 2015). Examples of search engines are Google, Bing, Yahoo!, and others. Users generally do not use many search engines at once to search. There are several criteria the user wants on the search engine, which is relevant results, a neat and orderly interface, and has the option to expand or narrow the search. Search engine results page (SERP) will display results from user search with a comfortable view so that users can spend about 6.4 seconds and choose from the search results (Cheng et al. 2017). Therefore, it is necessary that keywords in accordance with the needs of the community to be able to find information about the right tourism in the middle of this information age so that e-tourism can be done well.

In research conducted by (Ramaboa and Fish 2018), the keyword category is divided into two types, namely generic keyword, and branded keywords. User-generated search path usually starts with generic keyword then using specific keyword and ends with branded keyword. Society has its own curiosity. Therefore, the providers of tourism and travel bloggers who want to attract other travelers using search engines should be able to offer content that match the information sought by the community. Thus, the providers of tourism services, tourists, and travel bloggers can meet their needs and get responses from more customers.

In previous research, it was found the relationship between keywords used with the intention of the user when searching. Intention is a self-regulatory strategy that triggers goal-oriented behavior (Wu et al. 2011). Tourism information commonly sought by the public is maps, weather, traffic, accommodation, transportation, restaurants, shopping, and entertainment (Panadea et al. 2017). Therefore, this research is conducted to know what type of keywords are used by the community to search each type of tourism information along with its intention.

## Literature Review

### *Purchase Intention and Search Intention*

Someone formed an intention to engage to certain behaviors. Intention is the tendency to behave until the right time and opportunity arises so that the intention becomes an action. Intention may change from time to time. Intention is also influenced by attitudes toward behavior and subjective norms (Ajzen 2005). Behavior tends to be a routine or a habit that one does with a little conscious effort. Intention is an indication of how hard someone wants to try, how much effort is planned to be done, to perform certain behaviors. As a general rule, the more powerful a person intends to perform certain behaviors, the more likely they are to engage in such behavior (Ajzen 1991).

Gollwitzer (1999) proposed the theory of implementation intentions. This theory says that intention is a self-regulatory strategy that triggers goal-oriented behavior. This goal-oriented behavior allows multiple intentions to transform into a behavior. The act of purchasing a product is considered a goal-oriented behavior and obtaining information is considered a tool for implementing a behavior (implementation intention). The study found that the intention to buy the product (goal intention) occurs first before the intention to obtain a product information (implementation intention) and trigger a person to perform certain behaviors. When customers have an intention to buy a product, they will be inspired to search for information using keywords related to the product, so they can learn or know more about the product (Wu et al. 2011).

The intention to buy a product or called purchase intention is the willingness of the customer to purchase a product (Wu et al. 2011). There is a significant relationship between brand equity and the user's desire to recommend purchasing products from certain brands to others (Mirabi et al. 2015). Almost all previous studies tested the effect of a brand's image with a user's purchase intention and the results showed a significant relationship between the two variables (Mirabi et al. 2015). Intention to search means the desire of the customer to search using the keyword (Wu et al. 2011).

### *Consumer Search Behavior*

According to Cheng et al. (2017), customer experience is divided into three phases, namely pre-purchase, purchase, and post-purchase as in Figure 1. Moreover, based on Cheng et al. (2017), the customer is entering the introduction and learning stage of a particular brand during the pre-purchase stage. Online search impacts the customer experience. The variety of services offered makes the marketing researcher find the theory that information retrieval and evaluation at the pre-purchase stage for the sale of services differs from the sale of tangible products (Cheng et al. 2017). Tangible products can be observed based on product quality. Meanwhile, sales of services or intangible products are observed based on the quality of experience provided after or when the services are enjoyed. The search process for tangible products was not too deep, it has two stages namely the initiation of search to completion of the transaction. However, intangible products have longer and deeper search processes and can take up to two weeks to complete all online searches due to the influences of experience and quality of service provided (Cheng et al. 2017). Cheng, et al. (2017) emphasizes the use of branded keywords with generic keywords when searching because in general, keywords are categorized as generic and branded.

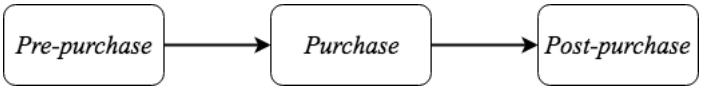


**Figure 1. Customer Experience**

### *Generic Search Query*

Customers who search using generic queries tend to still be in the early stages of the decision journey as in Figure 1. At this stage, customers still review the general services provided and comments about a brand that can satisfy their curiosity (Cheng et al. 2017). When the customer is still in the early stages of the decision journey, the customer's need for information dominates the search behavior. Even if the results are not accurate and in accordance with user-written queries, it will be deemed relevant to the customer's need to recognize the product. Examples of generic search queries in tourism area such as 'flight to Bali', 'unique lodging place in Bandung', 'shopping center at Jogjakarta', 'local restaurant in Jakarta', 'child friendly attractions in Raja Ampat', and so on.

### *Branded Search Query*

According to Cheng et al. (2017), customers see the brand name as a marker of quality service providers with considerable experience. This happens at the pre-purchase stage. Therefore, branded keywords tend to be more relevant to online service marketing. By the same logic, as customers expand their consideration for a particular brand, information about alternative brands becomes less relevant. It does not quite match the information required by the customer and may cause a decrease in the number of consumer response rates. When using branded queries, customer has reached the final stage of the decision journey (Cheng et al. 2017). From the point of view of a service provider or a tourist product, branded search queries are search queries containing the names of their services and products. For example, Garuda Indonesia as the flight service company provides the luxury flight experience in Indonesia. Search queries like 'Garuda airfare' and 'Garuda Indonesia to Bali' are branded search queries. If the search query used is other airline companies will not be included in the branded search query. Examples of the use of branded search queries are 'price of Citilink tickets to Bali', 'Harris hotel reviews in Bali', 'Rice Spicy Bu Andika Bali address', 'shopping tips at Sukowati Market Bali', 'Kecak Bali dance venue', and so on.

### *Tourism Information*

Study conducted by No and Kim (2015) found that the most often used keywords to search for travel experiences are transportation, accommodation, tourist attractions, and meal places. The internet is one of media used for searching such information. Transportation information that is usually sought-after is how to reach the destination, whether using land, sea, or air transportation. Information regarding restaurant usually sought is the list of restaurants in each city and country. For tourist attractions, the usual information sought after is a historic place, landmark or other attraction that becomes the tourist destination of the area (No and Kim 2015).

### *Conceptual Model Development*

Based on a study conducted on the review literature on purchase intentions and search intentions and the type of information that is usually needed in a tour. We compose a conceptual model for this research (Figure 2). This model will answer the research question, namely mapping the types of keywords used by potential tourists to meet their information needs to find or buy a tourist product or service.

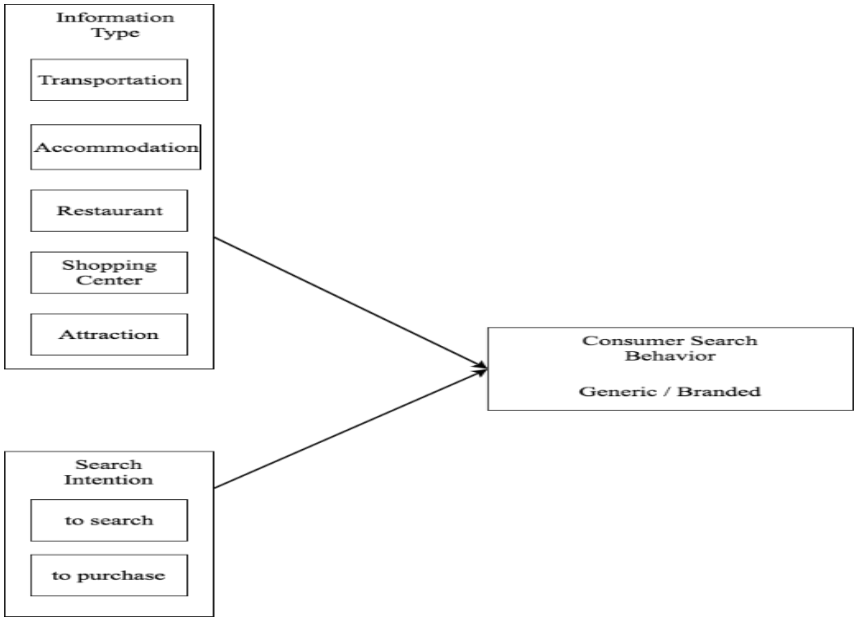


**Figure 2. Conceptual Model**

## Methodology

### *Research Approach*

This study uses a quantitative approach. One method that can be used for quantitative research approaches is to use surveys. A survey is one of the research approaches used to collect large amounts of data in a wide range. We use an online questionnaire to reach more respondents. The questionnaire is divided into two parts, namely the demographic section and the part that represents the questions related to the conceptual model. Demographic-related questions include e-mail or cellphone number, gender, age, domicile, latest education, employment, income, and so on.

The design of the second part of the questionnaire question was formed from a combination of several models in previous studies. We adopt the types of information that are usually sought by tourists from a study conducted by Panadea et al. (2017). The variables of this study are the type of information, type of intention, and type of keywords used by the user. The variables in this study are divided into two types, namely independent variables, and dependent variables. Independent variables in this study are type of information and type of intention. While the dependent variable in this study is the type of keyword used by users.

Furthermore, we conduct a readability test with seven prospective respondents and six of them came from the field of psychology at various universities. Readability tests are conducted on prospective respondents who come from the psychology field because prospective respondents have studied human nature and behavior and understand how to make the correct questionnaire items. At this stage, prospective respondents pay attention to each sentence contained in the questionnaire, ranging from informed consent to thank you. Prospective respondents gave criticism and suggestions regarding the questionnaire so as not to confuse respondents when the questionnaire was distributed. In addition, prospective respondents also pay attention to each item questionnaire rather do not have ambiguous words.

### *Sample, Population and Data Collection*

The population of this study is Indonesian people aged 13 to 54 years and have sought information about tourism, such as accommodation, transportation, restaurants, shopping places, and tourist attractions for as many as ten times a lifetime. We used purposive sampling for this study. Before

fulfilling the questionnaires, the respondents were asked if they had sought tourism information at least 10 times in their lifetime.

Questionnaires are distributed through social media such as Line, Whats App, Facebook, Twitter, and Instagram for approximately two months. The authors asked for online influencer help to post the survey link. Public influencer from Twitter did retweet the questionnaire link so it was expected that the respondents come from various regions in Indonesia with various other demographic categories. The link for the survey can be accessed in http://survey.ui.ac.id/536459.

## Result and Analysis

### *Respondent Demography*

We managed to get 1,259 respondents. However, there were three respondents who were invalid because they did not answer the questionnaire question completely in the research question section so that the total valid respondents were 1,256. In the demographic section, this questionnaire includes data on gender, age, education, occupation, income, domicile, type of travel undertaken, online media to search for tourism information, tourist destinations in Indonesia, and the frequency of travel per year. A summary of the respondent's demographics can be seen in Table 1. Most of the respondents are living in Greater Jakarta (52,9%), another 35,19% are living in Java Island. Thus, the result of the data analysis might only be representative for people live in Java and not Indonesian people.

**Table 1. Respondent Demography**

| Variable | Number (Percentage) | Variable | Number (Percentage) |
|---|---|---|---|
| **Gender** | | **Travel Frequency** | |
| Male | 398 (31.61%) | Never | 53 (4.21%) |
| Female | 861 (68.39%) | 1-2 times | 576 (45.75%) |
| **Age** | | 3-4 times | 434 (34.47%) |
| <20 years old | 157 (12.47%) | 5-6 times | 95 (7.55%) |
| 20-30 years old | 978 (77.68%) | >6 times | 101 (8.02%) |
| 31-40 years old | 86 (6.83%) | **Information searched** | |
| >40 years old | 38 (3.02%) | Accommodation | 1,091 (86.66%) |
| **Education** | | Transportation | 1,069 (84.91%) |
| School students | 466 (37.01%) | Restaurant | 561 (44.56%) |
| Diploma | 98 (7.78) | Shopping center | 433 (34.39%) |
| Bachelor's degree | 627 (49.80%) | Tourist attraction | 916 (72.76%) |
| Master's Degree | 65 (5.16%) | **Sources** | |
| Doctoral Degree | 3 (0.24%) | Offline | 1,199 (95.23%) |
| **Domicile** | | Online | 57 (4.53%) |
| Greater Jakarta | 666 (52,90%) | Unanswered | 3 (0.24%) |
| Outside Greater Jakarta (Java Island) | 443 (35,19%) | **Channel** | |
| Outside Java Island | 150 (11,91%) | Public site | 655 (52.03%) |
| **Occupation** | | Blog | 688 (54.65%) |
| Currently not working | 84 (6.67%) | Social Media | 1,012 (80.38%) |
| Student | 592 (47.02%) | Online travel agency site | 349 (27.72%) |
| Entrepreneur | 65 (5.16%) | Unanswered | 63 (5%) |
| Private Sector Employee | 387 (30.74%) | **Travel Destination** | |
| Civil Servant | 43 (3.42%) | Sabang | 151 (11.99%) |
| Others | 88 (6.99%) | Danau Toba | 251 (19.94%) |
| **Income in thousands of rupiahs** | | Padang | 199 (15.81%) |
| < 500 | 240 (19.06%) | Pahawang | 156 (12.39%) |
| 500 - 1000 | 207 (16.44%) | Bandung | 747 (59.33%) |
| 1000-5000 | 532 (42.26%) | Jogjakarta | 919 (72.99%) |
| 5000-10000 | 189 (15.01%) | Dieng | 393 (31.22%) |
| > 10000 | 88 (6.99%) | Malang | 669 (53.14%) |
| Unanswered | 3 (0,24%) | Banyuwangi | 290 (23.03%) |
| **Travel type** | | Derawan | 253 (20.10%) |
| *All-inclusive charter* | 28 (2.22%) | Bali | 767 (60.92%) |
| *Backpacker* | 362 (28.75%) | Sumba | 320 (25.42%) |
| *Group Travel* | 151 (11.99%) | Labuan Bajo | 442 (35.11%) |
| *Self-organized Trip* | 704 (55.92%) | Bunaken | 300 (23.83%) |
| Others | 14 (1.11%) | Raja Ampat | 445 (35.35%) |
| | | Others | 173 (3.74%) |

## *Aggregate Data Analysis*

Binary logistic regression analysis was used to test whether intention, type of information, age, domicile, last education, occupation, income, and frequency of trips per year predict consumer search behavior. The use of branded search queries is marked with 1 and the use of generic search queries is marked with 0. Purchase intention is marked with 1 and the intention to search is marked with 0. The use of branded search queries is associated with purchase intentions. This model explains that 26% (Nagelkerke R2) of the variance uses generic or branded search queries and successfully classifies 84.3% of all cases (Table 2 and Table 3).

**Table 2. Summary Model of Aggregate Data**

| Step | -2 Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
|---|---|---|---|
| 1 | 5006.803a | 0.180 | 0.261 |

**Table 3. Aggregate Data Classification**

| Observed | | | Predicted | | |
|---|---|---|---|---|---|
| | | | Keyword / Search Query | | Percentage Correct |
| | | | generic | branded | |
| Step 1 | Keyword / Search Query | generic | 3.742 | 1 | 100.0 |
| | | branded | 808 | 595 | 42.4 |
| Overall Percentage | | | | | 84.3 |

A variable can be said to be significant if the value in the Sig column is less than 0.05 with significance at the 5% level. The results of the regression analysis indicate that intention (B = 0.185, p <0.05) significantly influences consumer search behavior. A positive number in column B indicates that the intention variable tends to be significant for the use of branded search queries with purchase intention. Thus, it can be said that users with purchase intentions tend to use branded search queries with 6.390 times greater opportunities than users with search intentions.

In addition, the type of transportation information (B = 2.137, p <0.05) also significantly influences consumer search behavior for the use of branded search queries. Thus, it can be said that the type of transportation information tends to be searched using branded search queries with 8.474 times greater opportunities than the type of accommodation information. The type of shopping information (B = 0.151, p <0.05) also shows significance in the use of branded search queries. Therefore, it can be said that the type of information on shopping places tends to be searched using branded search queries with 2.227 times greater opportunities than the type of accommodation information. The type of tourist attraction information (B = 0.294, p <0.05) also shows significance in the use of branded search queries. Thus, it can be said that the type of information on tourist attractions tends to be searched using branded search queries with 1.342 times greater opportunities than the type of accommodation information. The results of the binary logistic regression test on the combined data can be seen in Table 4.

**Table 4. Binary Logistic Regression Test Results on Aggregated Data**

| | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Intention | 1.855 | 0.088 | 448.392 | 1 | 0.000 | 6.390 |
| Teen | -0.007 | 0.120 | 0.004 | 1 | 0.950 | 0.993 |
| Adult | 0.009 | 0.142 | 0.004 | 1 | 0.947 | 1.009 |
| Java | -0.052 | 0.082 | 0.399 | 1 | 0.528 | 0.950 |
| Non_java | 0.045 | 0.114 | 0.157 | 1 | 0.692 | 1.046 |
| In_School | 0.128 | 0.101 | 1.617 | 1 | 0.204 | 1.137 |
| Bachelor | -0.150 | 0.141 | 1.137 | 1 | 0.286 | 0.861 |
| Master | 0.055 | 0.161 | 0.115 | 1 | 0.735 | 1.056 |
| Not_working | 0.087 | 0.160 | 0.298 | 1 | 0.585 | 1.091 |
| Entrepreneur | 0.045 | 0.180 | 0.062 | 1 | 0.803 | 1.046 |
| Employee | 0.105 | 0.113 | 0.869 | 1 | 0.351 | 1.111 |
| Civil_servant | 0.380 | 0.215 | 3.121 | 1 | 0.077 | 1.463 |
| Other | -0.004 | 0.159 | 0.001 | 1 | 0.981 | 0.996 |
| Under500k | -0.152 | 0.116 | 1.723 | 1 | 0.189 | 0.859 |
| From500k_to1m | -0.104 | 0.113 | 0.856 | 1 | 0.355 | 0.901 |
| From5m_to10m | -0.224 | 0.117 | 3.635 | 1 | 0.057 | 0.799 |
| Above10m | 0.015 | 0.166 | 0.009 | 1 | 0.926 | 1.015 |
| Trans | 2.137 | 0.110 | 376.325 | 1 | 0.000 | 8.474 |
| Resto | 0.151 | 0.125 | 1.461 | 1 | 0.227 | 1.163 |
| Shop | 0.800 | 0.117 | 46.818 | 1 | 0.000 | 2.227 |
| Attr | 0.294 | 0.113 | 6.716 | 1 | 0.010 | 1.342 |
| Once | 0.105 | 0.187 | 0,314 | 1 | 0.576 | 1.111 |
| Four_times | 0.036 | 0.080 | 0,209 | 1 | 0.648 | 1.037 |
| Morethan_four times | 0.131 | 0.103 | 1,625 | 1 | 0.202 | 1.140 |
| Constant | -3.094 | 0.152 | 412,725 | 1 | 0.000 | 0.045 |

## *Information Type Data Analysis*

Data analysis per type of information was carried out to determine the characteristics of users based on the type of information. In addition, the results of data analysis per type of information can show whether each type of information has different influencing factors. Data analysis per type of information was carried out with the assumption that demographic variables have a different effect on each type of information on consumer search behavior. For data per type of information, the dependent variable is consumer search behavior (generic/branded) with the independent variables being intention (to search/to purchase), age, domicile, last education, occupation, income, and frequency of trips per year.

Binary logistic regression analysis was used to test whether intention, type of information, age, domicile, last education, occupation, income, and annual travel frequency predict consumer search behavior. The use of branded search queries is marked with 1 and the use of generic search queries is marked with 0. Purchase intention is marked with 1 and the intention to search is marked with 0. The use of branded search queries is associated with purchase intention.

### *Analysis of Transportation Information Type*

This model explains that 42% (Nagelkerke R2) of the variance uses generic or branded search queries and successfully classifies 85.5% of all cases (Table 5). The results of the regression analysis indicate that intention (B= 0.287, p> 0.05) does not significantly affect consumer search behavior because the p-value or value in the Sig column exceeds 0.05. In addition, users who live outside Greater Jakarta (Java Island) (B= -0.446, p<0.05) significantly influence consumer search behavior. However, a negative number in column B indicates that users outside Greater Jakarta (Java Island) tend to use generic search queries with a 0.640 times greater chance than users who live in Greater Jakarta to search for types of transportation information.

**Table 5. Binary Logistic Regression Test Results on Transportation Data**

| | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Intention | 0.287 | 0.172 | 2.792 | 1 | 0.095 | 1.332 |
| Teen | 0.128 | 0.280 | 0.207 | 1 | 0.649 | 1.136 |
| Adult | 0.528 | 0.321 | 2.705 | 1 | 0.100 | 1.695 |
| Java | -0.446 | 0.206 | 4.679 | 1 | 0.031 | 0.640 |
| Non_java | -0.040 | 0.258 | 0.024 | 1 | 0.876 | 0.960 |
| In_School | -0.203 | 0.241 | 0.707 | 1 | 0.400 | 0.817 |
| Bachelor | -0.770 | 0.421 | 3.348 | 1 | 067 | 0.463 |
| Master | 0.279 | 0.357 | 0.610 | 1 | 0.435 | 1.322 |
| Not_working | -0.401 | 0.401 | 1.003 | 1 | 0.317 | 0.669 |
| Entrepreneur | 0.083 | 0.429 | 0.037 | 1 | 0.847 | 1.086 |
| Employee | -0.001 | 0.277 | 0.000 | 1 | 0.998 | 0.999 |
| Civil_servant | -0.469 | 0.580 | 0.656 | 1 | 0.418 | 0.625 |
| Other | -0.048 | 0.379 | 0.016 | 1 | 0.900 | 0.953 |
| Under500k | 0.339 | 0.270 | 1.574 | 1 | 0.210 | 1.403 |
| From500k_to1m | -0.099 | 0.285 | 0.120 | 1 | 0.729 | 0.906 |
| From5m_to10m | -0.220 | 0.284 | 0.602 | 1 | 0.438 | 0.802 |
| Above10m | -0.131 | 0.381 | 0.118 | 1 | 0.731 | 0.877 |
| Once | 0.324 | 0.383 | 0.714 | 1 | 0.398 | 1.382 |
| Four_times | -0.186 | 0.189 | 0.960 | 1 | 0.327 | 0.831 |
| Morethan_four times | -0.543 | 0.282 | 3.717 | 1 | 0.054 | 0.581 |
| Constant | -1.604 | 0.279 | 33.182 | 1 | 0.000 | 0.201 |

*Analysis of Accommodation Information Type*

This model explains that 52% (Nagelkerke R2) of the variance uses generic or branded search queries and successfully classifies 84.8% of all cases (Table 6). The results of the regression analysis indicate that intention (B= -0.161, p>0.05) does not significantly affect consumer search behavior because the p-value or value in the Sig column exceeds 0.05. In addition, users who are under 20 years old (B = 0.657, p <0.05) significantly influence consumer search behavior. Users under the age of 20 tend to use branded search queries with a 1,930 times greater chance than users aged 20-30 to search for types of accommodation information.

**Table 6. Binary Logistic Regression Test Results on Accommodation Data**

| | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Intention | -0.161 | 0.171 | 0.890 | 1 | 0.346 | 0.851 |
| Teen | 0.657 | 0.249 | 6.975 | 1 | 0.008 | 1.930 |
| Adult | 0.573 | 0.314 | 3.333 | 1 | 0.068 | 1.773 |
| Java | -0.115 | 0.193 | 0.356 | 1 | 0.551 | 0.891 |
| Non_java | 0.155 | 0.264 | 0.344 | 1 | 0.558 | 1.168 |
| In_School | 0.232 | 0.240 | 0.936 | 1 | 0.333 | 1.261 |
| Bachelor | 0.268 | 0.315 | 0.723 | 1 | 0.395 | 1.308 |
| Master | 0.095 | 0.382 | 0.062 | 1 | 0.803 | 1.100 |
| Not_working | -0.062 | 0.409 | 0.023 | 1 | 0.880 | 0.940 |
| Entrepreneur | 0.361 | 0.408 | 0.782 | 1 | 0.376 | 1.435 |
| Employee | 0.145 | 0.281 | 0.265 | 1 | 0.606 | 1.156 |
| Civil_servant | 0.427 | 0.489 | 0.763 | 1 | 0.383 | 1.532 |
| Other | 0.342 | 0.368 | 0.860 | 1 | 0.354 | 1.407 |
| Under500k | 0.177 | 0.266 | 0.443 | 1 | 0.506 | 1.194 |
| From500k_to1m | 0.246 | 0.258 | 0.913 | 1 | 0.339 | 1.279 |
| From5m_to10m | -0.421 | 0.313 | 1.808 | 1 | 0.179 | 0.656 |
| Above10m | 0.449 | 0.355 | 1.598 | 1 | 0.206 | 1.566 |
| Once | 0.380 | 0.387 | 0.963 | 1 | 0.326 | 1.462 |
| Four_times | -0.027 | 0.194 | 0.020 | 1 | 0.888 | 0.973 |
| Morethan_four times | 0.419 | 0.229 | 3.338 | 1 | 0.068 | 1.520 |
| Constant | -2.139 | 0.292 | 53.486 | 1 | 0.000 | 0.118 |

*Analysis of Restaurant Information Type*

This model explains that 39% (Nagelkerke R2) of the variance uses generic or branded search queries and successfully classifies 82.5% of all cases (Table 7). The results of the regression analysis indicate that intention (B= 0.475, p> 0.05) does not significantly affect consumer search behavior because of the p-value or value in the Sig column. greater than 0.05. In addition, there are no other variables that are significant to consumer search behavior.

**Table 7. Binary Logistic Regression Test Results on Restaurant Data**

| | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Intention | 0.475 | 0.193 | 6.075 | 1 | 0.014 | 1.608 |
| Teen | -0.091 | 0.333 | 0.075 | 1 | 0.784 | 0.913 |
| Adult | 0.145 | 0.347 | 0.175 | 1 | 0.675 | 1.156 |
| Java | 0.058 | 0.213 | 0.073 | 1 | 0.787 | 1.059 |
| Non_java | 0.272 | 0.283 | 0.925 | 1 | 0.366 | 1.312 |
| In_School | -0.022 | 0.259 | 0.007 | 1 | 0.932 | 0.978 |
| Bachelor | -0.046 | 0.346 | 0.018 | 1 | 0.895 | 0.955 |
| Master | -0.346 | 0.465 | 0.553 | 1 | 0.457 | 0.708 |
| Not_working | -0.361 | 0.460 | 0.618 | 1 | 0.432 | 0.697 |
| Entrepreneur | 0.384 | 0.430 | 0.795 | 1 | 0.372 | 1.468 |
| Employee | 0.315 | 0.287 | 1.199 | 1 | 0.273 | 1.370 |
| Civil_servant | 0.741 | 0.523 | 2.007 | 1 | 0.157 | 2.099 |
| Other | -0.284 | 0.447 | 0.403 | 1 | 0.525 | 0.753 |
| Under500k | -0.196 | 0.320 | 0.377 | 1 | 0.539 | 0.822 |
| From500k_to1m | -0.059 | 0.297 | 0.039 | 1 | 0.843 | 0.943 |
| From5m_to10m | 0.010 | 0.279 | 0.001 | 1 | 0.972 | 1.010 |
| Above10m | -0.919 | 0.481 | 3.468 | 1 | 0.056 | 0.399 |
| Once | -0.433 | 0.560 | 0.598 | 1 | 0.439 | 0.648 |
| Four_times | 0.003 | 0.203 | 0.000 | 1 | 0.990 | 1.003 |
| Morethan_four times | -0.061 | 0.268 | 0.053 | 1 | 0.819 | 0.940 |
| Constant | -1.879 | 0.312 | 36.156 | 1 | 0.000 | 0.153 |

*Analysis of Shopping Centre Information Type*

This model explains that 44% (Nagelkerke R2) of the variance uses generic or branded search queries and succeeds in classifying 72.3% of all cases (Table 8). The results of the regression analysis indicate that intention ($B = 0.457$, $p < 0.05$) significantly influences consumer search behavior. A positive number in column B indicates that the intention variable tends to be significant for the use of branded search queries with purchase intention. Thus, it can be said that users with purchase intention tend to use branded search queries with 1,580 times greater opportunities than users with intention to search on the type of shopping information. In addition, there are no other variables that are significant to consumer search behavior.

**Table 8. Binary Logistic Regression Test Results on Shopping Centre Data**

| | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Intention | 0.457 | 0.164 | 7.752 | 1 | 0.005 | 1.580 |
| Teen | 0.037 | 0.255 | 0.021 | 1 | 0.885 | 1.038 |
| Adult | -0.527 | 0.350 | 2.273 | 1 | 0.132 | 0.590 |
| Java | -0.039 | 0.184 | 0.044 | 1 | 0.833 | 0.962 |
| Non_java | 0.184 | 0.244 | 0.570 | 1 | 0.450 | 1.202 |
| In_School | 0.208 | 0.217 | 0.915 | 1 | 0.339 | 1.231 |
| Bachelor | -0.715 | 0.368 | 3.776 | 1 | 0.052 | 0.489 |
| Master | 0.413 | 0.361 | 1.311 | 1 | 0.252 | 1.512 |
| Not_working | -0.001 | 0.345 | 0.000 | 1 | 0.998 | 0.999 |
| Entrepreneur | 0.133 | 0.409 | 0.105 | 1 | 0.746 | 1.142 |
| Employee | 0.057 | 0.244 | 0.055 | 1 | 0.814 | 1.059 |
| Civil_servant | -0.262 | 0.534 | 0.241 | 1 | 0.623 | 0.769 |
| Other | -0.191 | 0.359 | 0.282 | 1 | 0.595 | 0.826 |
| Under500k | -0.201 | 0.255 | 0.622 | 1 | 0.430 | 0.818 |
| From500k_to1m | -0.103 | 0.243 | 0.180 | 1 | 0.672 | 0.902 |
| From5m_to10m | -0.350 | 0.273 | 1.652 | 1 | 0.199 | 0.704 |
| Above10m | 0.305 | 0.401 | 0.579 | 1 | 0.447 | 1.357 |
| Once | 0.030 | 0.382 | 0.006 | 1 | 0.938 | 1.030 |
| Four_times | 0.011 | 0.176 | 0.004 | 1 | 0.951 | 1.011 |
| Morethan_four times | 0.067 | 0.236 | 0.082 | 1 | 0.775 | 1.070 |
| Constant | -1.194 | 0.258 | 21.356 | 1 | 0.000 | 0.303 |

*Analysis of Tourist Attraction Information Type*

This model explains that 53% (Nagelkerke R2) of the variance uses generic or branded search queries and succeeds in classifying 77.3% of all cases (Table 9). The results of the regression analysis indicate that intention ($B = 0.544$, $p < 0.05$) significantly influences consumer search behavior. Therefore, it can be said that users with purchase intentions tend to use branded search queries with 1.724 times greater opportunities than users with search intentions.

In addition, age under 20 years ($B = -0.309$, $p<0.05$) also significantly influences consumer search behavior for the use of generic search queries. Negative numbers in column B indicate that the age category under 20 years tends to use generic search queries. Therefore, it can be said that those under the age of 20 tend to use generic search queries with a chance of 0.539 times greater than the age category of 20 to 30 years. Users who earn IDR 5,000,000.00 to IDR 10,000,000.00 ($B = -0.398$, $p<0.05$) also influence consumer search behavior. So that it can be said that users with an income category of IDR 5,000,000.00 to IDR 10,000,000.00 tend to use generic search queries with 0.534 times greater opportunities than users with an income category of IDR 1,000,000.00 to IDR 5,000,000.00.

**Table 9. Binary Logistic Regression Test Results on Shopping Centre Data**

| | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Intention | 0.544 | 0.186 | 8.577 | 1 | 0.003 | 1.724 |
| Teen | -0.618 | 0.282 | 4.795 | 1 | 0.029 | 0.539 |
| Adult | -0.309 | 0.338 | 0.835 | 1 | 0.361 | 0.734 |
| Java | 0.012 | 0.175 | 0.005 | 1 | 0.944 | 1.012 |
| Non_java | 0.008 | 0.250 | 0.001 | 1 | 0.975 | 1.008 |
| In_School | 0.173 | 0.212 | 0.670 | 1 | 0.413 | 1.189 |
| Bachelor | -0.294 | 0.336 | 0.764 | 1 | 0.382 | 0.745 |
| Master | -0.410 | 0.375 | 1.193 | 1 | 0.275 | 0.664 |
| Not_working | 0.028 | 0.360 | 0.006 | 1 | 0.938 | 1.029 |
| Entrepreneur | -0.666 | 0.447 | 2.221 | 1 | 0.136 | 0.514 |
| Employee | 0.030 | 0.233 | 0.016 | 1 | 0.898 | 1.030 |
| Civil_servant | 0.680 | 0.445 | 2.338 | 1 | 0.126 | 1.973 |
| Other | 0.067 | 0.335 | 0.040 | 1 | 0.842 | 1.069 |
| Under500k | -0.252 | 0.246 | 1.049 | 1 | 0.306 | 0.777 |
| From500k_to1m | -0.398 | 0.243 | 2.682 | 1 | 0.101 | 0.672 |
| From5m_to10m | -0.628 | 0.265 | 5.597 | 1 | 0.018 | 0.534 |
| Above10m | -0.066 | 0.358 | 0.034 | 1 | 0.854 | 0.936 |
| Once | -0.219 | 0.438 | 0.250 | 1 | 0.617 | 0.803 |
| Four_times | 0.284 | 0.170 | 2.806 | 1 | 0.094 | 1.329 |
| Morethan_four times | 0.084 | 0.226 | 0.139 | 1 | 0.709 | 1.088 |
| Constant | -1.497 | 0.267 | 31.545 | 1 | 0.000 | 0.224 |

## Discussion

Based on the results of the binary logistic regression test it was found that intention positively influences the user in choosing to use branded or generic search queries. Intention is declared significant influence the user to use branded or generic search queries. Users with purchase intentions tend to use branded search queries 6,390 times compared to users with search intentions. This is in accordance with Wu et al. (2011). Overall, not all types of information influence positively users in choosing to use branded or generic search queries. Only types of information on transportation, shopping places, and tourist attractions have a significant impact. The type of transportation information tends to be searched more by users using branded search queries compared to the type of accommodation information. The type of information on shopping places tends to be searched more by users using branded search queries compared to the type of accommodation information. Types of tourist attraction information tend to be searched more by users using branded search queries with compared to the type of accommodation information. Demographic variables such as age, last education, domicile, occupation, income, and annual travel frequency do not have a significant effect on the use of generic or branded search queries.

Based on the type of transportation information, variables that affect usage generic or branded search query is domicile. Users outside Greater Jakarta tends to use generic search queries compared to users in Greater Jakarta. From this result we could imply that when searching transportation information, people from Greater Jakarta seems to be more certain on what they want to use for their travel journey. Living in the capital of the nation might have influence on people knowledge of the transportation variety and their reputation. However, this result needs to be confirmed in the future research.

Based on the type of accommodation information, the variable that influences the use of generic or branded search queries is age. Users under the age of 20 are more likely to use branded search queries than users aged 20 to 30. Young people tend to be more impulsive to make a purchase are also more easily influenced by a new, latest, and popular lifestyle (Abdul and Cloud 2015). Thus, they are more likely to used branded keyword when searching for travel information on the internet.

Based on the type of restaurant information, there are no influencing variables use of generic or branded search queries. This may be caused by a person's decision-making style that influences user behavior for buy something. Users have different perceptions when they want to make a purchase at a restaurant.

This is because each restaurant offers products that are intangible and perishable. According to Seo and Moon (2016) advanced users' innovation does not only tend to look for unique foods. On the contrary, less innovative users tend to be more difficult to convert belief about a product. This also affects intention users to make purchases online (Seo and Moon 2016). Based on the type of shopping information, the influencing variables users in using generic or branded search queries are intentional. Thus, it can be concluded that users with purchase intention tend to search for types of shopping information using branded search queries compared to users with intention to search.

For the type of tourist attraction information, there are three influencing variables users in using generic or branded search queries. There are intention, age, and income. For variables intention, users with purchase intention tend to use branded search queries to find types of information on tourist attractions compared to users with the intention to search. The category of users aged less than 20 years influences users to use generic or branded search to find types of information on tourist attractions. Based on the data above, it can be concluded that the user those under the age of 20 tend to use generic search queries compared to users aged 20-30 years. Young age tends to influence the use of generic or branded search queries on search engines because users at a young age tend to be more impulsive in making purchases. Young people are also more easily influenced by new lifestyles to become something new (novelty) and the latest fashion (Abdul and Awan 2015). Abdul and Awan (2015) also found that users with high income rates tend to be more impulsive in making purchases. Users with higher education also tend to be more impulsive to make purchases.

Trends in the world of tourism show that the number of tourists who use the internet to find itinerary ideas and compare flight ticket prices. Since 2016, tourists have started using search engines and YouTube as a place to find ideas and inspiration for their vacation. Although almost all travelers book on desktop, they are more likely to search on mobile devices (Google 2016). Before going on a tour, tourists generally do research to find out all the possibilities in traveling. More than 40% of tourists say that they often change their choice of travel destination by looking for detailed information about a tourist destination and then considering other options and the traveler's customer journey have objective to find micro-moments. This moment is the moment when the user uses his device to immediately get the answer to his curiosity. This moment can be used as a bet for providers of tourism products and services so that they can become user references so that they choose to use products and services from these providers. What happens in these micro-moments will determine the decision-making process to do tourism. For marketers, this moment is appropriate to shape the customer travel journey through various devices and channels (Google 2016).

As many as 72% of tourists who use their smartphone to search for information, they expect relevant information compared to what company provides this information. In other words, they are more loyal to their desires than any other brand. As many as 78% of tourists do not know what airline they will go with and as many as 82% of tourists have not booked accommodation at their destination when tourists have the desire to travel, they have not even decided where they will travel. The current moment is a valuable moment that can be maximized by providers of tourism products and services to get impressions (Google 2016).

One of the trends in the world of digital marketing in the tourism industry is the use of Search Engine Optimization (SEO). SEO is an attempt to increase the quality and quantity of traffic to websites through organic search results. One way to implement SEO is to do it using SEO keywords. SEO keywords are words or sentences in the content of a site that make it possible for the site to be found by users when searching on search engines. Keywords are the main key to implementing SEO (Wordstream 2015). Providers of tourism products or services can follow trends digital marketing by implementing SEO on the site or on the product and services offered. The keywords used can be generic or branded. In addition, providers of tourism products or services can consider other things such as intention, type of information offered, and demographic variables to determine the type of keyword used. For information type transportation, branded keywords can be selected for the target market aged under 20 years. For accommodation information types, branded keywords can be selected for the target markets domiciled outside Greater Jakarta (Java Island). For information type shopping malls, branded keywords can be chosen to target users who already want to make a purchase. For the type of tourist attraction information, branded keywords can be chosen to target users who have purchase intention. Not only

that, but the use of branded keywords can also be used to target users under the age of 20 or users with income of IDR 5,000,000.00 to. IDR 10,000,000.00 per month. Product or service providers should not only focus on branded search queries. Through generic search queries, product or service providers can analyze and understand traffic on generic search queries because they are generally frequent represents a new or unique visitor to the provider's site the product or service. Those visitors might visitors who do not yet know the brand of the product or service provider however looking for products or services offered (Risdall 2018).

## Limitation and Future Research

This study has limitation on the respondent demography especially on occupation and domicile category. This study only uses quantitative approaches to analyze the utilization of branded and generic keyword search for five travel information. Thus, future research with different approaches (qualitative) might be useful to enrich the result of this type of study.

## Conclusion

This study found that intention influence users in choosing to use generic or branded search queries as a whole. However, not all types of information matter users in choosing to use generic or branded search queries. From the research results, it is known that only the type of transportation and place information spending that influences users in choosing to use generic or branded search queries. When reviewed based on each information type, there are other variables that also affect the inner user choose to use generic or branded search queries. In the type of transportation information, the domicile variable is especially for users who live outside Greater Jakarta (Java Island) has a significant impact on users in choosing to use generic or branded search queries.

In the type of accommodation information, the age variable is especially for users who are under 20 years of significant impact on the users of the users in choose to use generic or branded search queries. on type information on shopping places, the intention variable has a positive effect significant for users in choosing to use generic or branded search queries. In the type of tourist attraction information, variable intention, age with category under 20 years, and income in the category of IDR 1,000,000.00 to. IDR 5,000,000.00 has a significant impact on internal users choose to use generic or branded search queries.

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# Analysis of ERP Critical Failure Factors: A Case Study in an Indonesian Mining Company

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## Abstract

*ERP is a useful application for companies to run day-to-day operations by automating business processes, but the complexity and difficulty of deploying ERP systems causes unanticipated implementation failures. Around 70% of ERP implementation fails to produce the expected benefits, and three-quarters of these projects fail. This study aims to uncover potential reasons that cause the failure of ERP system adoption using Company XYZ, a mining company as the case. A questionnaire was distributed to its management and employees. TOPSIS approach was used to rank the variables according to their significance in affecting the failure of ERP systems implementation. The findings revealed that the two most important critical failure causes for ERP implementation are a bad understanding of the organization's business processes and poor business process reengineering. The company needs to conduct a deeper analysis of the existing business processes in the business unit to be able to determine more appropriate business process reengineering for ERP implementation in the future. Companies and academics can utilize the study's findings as a helpful resource to identify the cause of ERP implementation failure.*

**Keywords:** ERP (Enterprise Resource Planning), CFF (Critical Failure Factors), TOPSIS, Failure Implementation ERP, Mining Company

## Introduction

ERP system is a software application that enables the integration of data to support a typical company's main functions (Kirmizi and Kocaoglu 2020; Motiwalla and Thompson 2012). ERP is used by businesses to get visibility into their company processes and to be prepared for various dynamic situations (Goundar 2021). Companies can integrate all business processes into one system using ERP (Motiwalla and Thompson 2012). ERP also allows companies to have accurate, real-time, and

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accountable data (Ahmad and Mehmood 2020). This capability supports companies to have good corporate governance standards, bring a lot of profits to companies, and increase their efficiency.

Although ERP is a very useful application for companies, many organizations have failed to deploy and implement ERP systems. Failure in ERP implementation remains frequent to produce the expected advantages (Chakravorty et al. 2016; Jaeger et al. 2020; Panji Wicaksono et al. 2022). ERP implementation failures are not only experienced by small companies, but multinational companies such as Nike, Hershey, etc. as well (Amid et al. 2012).

The success or failure of ERP systems adoption is influenced by several factors (Kirmizi and Kocaoglu 2020). However, previous studies have been focusing on critical success factors (CSFs), which are one of the most used terms in ERP system literature (Amid et al. 2012), with fewer studies attempting to identify critical failure factors. According to (Prasetyo et al. 2019) just 6% of all ERP articles presented CSF while studies examining ERP CFF were fewer than 1%. It should be noted that reviewing and analyzing ERP failure experiences through research initiatives is extremely beneficial for preventing future missteps (Mahmood et al. 2020). As a result, failure analysis, particularly CFF in ERP system implementation, can be considered a research concern.

Many companies have implemented ERP applications to gain a competitive advantage, including Company XYZ Company XYZ is a mining company in Indonesia that has multiple businesses. It provides sales of precious metals, nickel, coal, bauxite, and exploration services. Company XYZ has six business units spread across five provinces in Indonesia. All business units are under the auspices of the head office in Jakarta, Indonesia.

Company XYZ has implemented ERP in its head office and all business units since 2016 to support its digitalization transformation solutions. The company selected SAP, which is widely used by large companies in Indonesia (Muhtar 2022). SAP includes business processes derived from best practices that are readily used by the company. These applications help mining companies manage production reports, improve transportation and logistics efficiency, manage company assets, and create financial reports. Using ERP, it is easier to integrate and track data between departments and improve data visibility. A higher quality and more accurate data produced by ERP leads to improved analysis to support management decision-making.

Implementation of ERP began in 2017 and went live in 2018. Implementation and go-live went smoothly but after go-live, it was realized that there were some unidentified problems. This can be seen from the financial statement issued by the ERP system which is incorrect and cannot be accepted by the auditor. The implementor consultant reviewed the implemented business processes but could not find the cause of the implementation failure. This failure caused obstacles in the company's operations because they still had to manually record and calculate financial reports from existing transactions.

Many failures and successes of ERP implementation have been discussed in previous studies (Amid et al. 2012; Chakravorty et al. 2016; Gargeya and Brady 2005; Ghayas et al. 2022; Hong and Kim 2002; Jaeger et al. 2020; Jarrar et al. 2000; Kumar and Gupta 2012; Yadav et al. 2020; Malaurent and Avison 2015; Motiwalla and Thompson 2012; Panji Wicaksono et al. 2022; Peci and Važan 2014; Prasetyo et al. 2019; Ravasan and Mansouri 2014; Umble et al. 2003; Wong et al. 2005; Xue et al. 2005). Research by Prasetyo et al. (2019) discussed the critical failure factors of ERP implementation in a company, it is necessary to evaluate the failure of ERP implementation so that the company knows the mistakes made and prevents failures in the next implementation (Prasetyo et al. 2019).

Therefore, this research was conducted to investigate the most significant factors causing the failure of ERP implementation or critical failure factors (CFF). ERP CFFs were analyzed using questionnaire data and prioritized using the TOPSIS method. The primary factors obtained from the research results can be used as a reference for decision-making to improve the re-implementation of the business unit so that the chance of failed ERP implementation can be reduced.

Despite its popularity, ERP implementations continue to fail at a high rate. According to (Prasetyo et al. 2019), ERP implementation failure is still on a scale of 67-90%. Meanwhile, compared to the Critical Success Factors (CSF) aspect, the Critical Failure Factors are rarely discussed by previous studies.

Another survey reported that 70% of ERP implementations fail to produce the expected benefits (Al-Mashari 2000).

Several previous studies discussed the failure of ERP implementation from various perspectives. There are many ERP implementation failures in famous companies like Hewlett Packard, Nike, and Fox Meyer Drugs, which the latter ended up bankrupt. Hewlett-Packard lost $160 million and Nike $100 million (Peci and Važan 2014). Research by (Wong et al. 2005) showed that there are 14 critical failure factors in ERP implementation. The research conducted by (Amid et al. 2012) identified and categorized 35 critical failure factors of ERP implementation in companies in Iran.

Several methods can be used to determine the critical failure factors of ERP such as Robust EFA, TOPSIS, and Fuzzy Dematel. The Robust EFA method is often used to determine the most dominant factor among other factors, in this case, the most dominant factor causing ERP implementation failure. A study by (Amid et al. 2012) used Robust EFA to identify patterns in multidimensional entities that are then applied to the creation of measurement scales. Its main goal is to condense many observed variables into a smaller set of components to improve interpretability and find hidden structures in the data. Then in the research conducted by (Prasetyo et al. 2019), the data analysis method was not specifically stated but it was explained that data analysis was carried out using the SmartPLS and SPSS applications. In a separate study (Yadav et al. 2020), data analysis was carried out by using the TOPSIS method to get the highest ranking that caused the failure of ERP implementation. The TOPSIS method is one of the most widely used techniques for multi-criteria decision-making analysis (Yadav et al. 2020). In another study by Visalakshmi et al. (2015) Fuzzy DEMATEL TOPSIS was used to evaluate the financial performance of GREENEX industries (Visalakshmi et al. 2015). A framework structured on accounting-based financial performance using sixteen financial ratios to rank fourteen different companies was proposed. Weights were assigned to criteria and sub-criteria using the DEMATEL methodology, with ranking done using the TOPSIS method. The analysis helps the revision of financial information as well as the financial position of the best firms (Visalakshmi et al. 2015).

## Research Method

The research method used in this study is in line with the research objective, which is to obtain the most crucial factor affecting the failure of ERP implementation using the TOPSIS method. Based on the literature review, there were 35 critical failure factors and their categories are seen in the Appendix. Then a questionnaire was developed by adopting these factors to collect data. Afterward, the collected data was prioritized according to its significance in affecting ERP implementation failure using the TOPSIS method.

A questionnaire was developed to examine the factors adopted from (Amid et al. 2012). Primary data were collected through a structured questionnaire using a five-point Likert scale. Respondents gave responses from 1 to 5, where 1 means irrelevant, 2 is less relevant, 3 is quite relevant, 4 is more relevant and 5 very relevant. This research uses purposive sampling. The total number of samples was 62, taken from employees to management at the head office and the processing precious metals business unit who were involved in ERP implementation, especially the key users of the project. The research design can be seen in Figure 1.

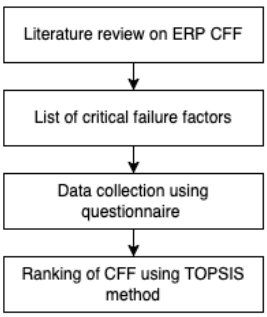


**Figure 1. Research Design**

TOPSIS is one of the most widely used strategies for determining the relative importance of several options (Hwang and Masud 1979). TOPSIS is used in this research because is the most effective, straightforward, and practical multi-criteria decision-making method, this method has also been successfully used to rank ERP critical failure factors in previous studies (Yadav et al. 2020). According to this technique, a positive ideal solution maximizes the benefit criterion while minimizing the cost criteria, whereas a negative ideal solution maximizes the cost criteria while minimizing the benefit criteria. TOPSIS is the most powerful multicriteria decision-making tool available, and it's also the most basic and straightforward to use (Ballı and Korukoğlu 2009). The TOPSIS method is broken down into seven steps, as follows (Assari et al. 2012).

1) Construct the decision matrix (A). The purpose of this matrix is to get the normalized value of the existing parameters.

$$A = (a_{ij})m_x n = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{21} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \quad \text{Equation (1)}$$

2) Calculate the decision matrix that has been normalized. The adjusted value Pij is determined as follows:

$$P_{ij} = \frac{A_{ij}}{\sqrt{\sum_{i=1}^{m} {A_{ij}}^2}} \quad \text{Equation (2)}$$

3) Calculate the normalized weighted decision matrix. The following formula is used to calculate the weighted normalized value vij:

$$v_{ij} = P_{ij}\, x\, w_j \quad \text{Equation (3)}$$

where $v_{ij}$ is the weight of the $j^{th}$ criterion and $\sum_{j=1}^{n} w_j = 1$

4) Determine the solutions for the positive ideal (A*) and negative ideal (A–).

$$A^* = \{(\max v_{ij}), (\max v_{ij})_{,i,j=1,2,\ldots,m}\} = \{v_{1+}, v_{2+}, \ldots v_{n+}\} \quad \text{Equation (4)}$$

$$A^- = \{(\min v_{ij}), (\min v_{ij})_{,i,j=1,2,\ldots,m}\} = \{v_{1-}, v_{2-}, \ldots v_{n-}\} \quad \text{Equation (5)}$$

5) Determine the separation measures of each alternative from the positive and negative ideal solutions, respectively.

$$Si^* = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^*)^2, j = 1,2, \ldots, m} \quad \text{Equation (6)}$$

$$Si^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2, j = 1,2, \ldots, m} \quad \text{Equation (7)}$$

6) Calculate the relative closeness to the ideal solution. The degree to which the alternative Ai is similar to A* is defined as follows:

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-}, i = 1,2, \ldots, m \quad \text{Equation (8)}$$

7) Rank the preference order.

The last step is to rank the critical failure factors to determine the most significant one in affecting ERP implementation. Further explanation about the TOPSIS method can be seen in (Assari et al. 2012). In this study, the factors causing implementation failure were ranked from the most significant to the least.

## Result and Discussion

The data collected from the respondents is shown in Table 1. For each factor, the table shows the number of respondents who filled in each option. For example, for the first factor, 12 respondents filled in "irrelevant", 17 respondents filled in "less relevant", 28 respondents filled in "quite relevant", 3 respondents filled in "more relevant", and 2 respondents filled in "very relevant". In total, there are 62 responses for each factor. Data collected from the questionnaire was processed using the TOPSIS method according to the steps described in the previous section to identify the most significant factors. Table 2 shows the weight value calculation method of TOPSIS after calculation in step 1. The results of the decision matrix showed that the total value was 1, which meant the value of the questionnaire parameters was appropriate. The derived weight value was used to prioritize the critical failure factors.

**Table 1. Respondent responses from the questionnaire**

| Factor No. | Irrelevant | Less Relevant | Quite Relevant | More Relevant | Very Relevant |
|---|---|---|---|---|---|
| 1 | 12 | 17 | 28 | 3 | 2 |
| 2 | 13 | 32 | 11 | 2 | 4 |
| 3 | 6 | 17 | 22 | 11 | 6 |
| 4 | 16 | 30 | 11 | 3 | 2 |
| 5 | 4 | 22 | 26 | 6 | 2 |
| 6 | 32 | 20 | 7 | 2 | 1 |
| 7 | 26 | 23 | 6 | 5 | 2 |
| 8 | 30 | 24 | 4 | 3 | 1 |
| 9 | 13 | 21 | 26 | 1 | 1 |
| 10 | 38 | 16 | 3 | 3 | 2 |
| 11 | 10 | 12 | 36 | 3 | 1 |
| 12 | 6 | 10 | 28 | 12 | 6 |
| 13 | 12 | 26 | 16 | 6 | 2 |
| 14 | 37 | 20 | 2 | 1 | 2 |
| 15 | 20 | 16 | 18 | 6 | 2 |
| 16 | 4 | 4 | 12 | 22 | 20 |
| 17 | 14 | 12 | 26 | 8 | 2 |
| 18 | 20 | 18 | 9 | 8 | 7 |
| 19 | 4 | 8 | 20 | 18 | 12 |
| 20 | 2 | 7 | 22 | 21 | 10 |
| 21 | 11 | 16 | 18 | 10 | 7 |
| 22 | 25 | 23 | 10 | 3 | 1 |
| 23 | 19 | 20 | 10 | 8 | 5 |
| 24 | 25 | 10 | 8 | 11 | 8 |
| 25 | 20 | 16 | 18 | 5 | 3 |
| 26 | 16 | 12 | 30 | 3 | 1 |
| 27 | 6 | 22 | 20 | 8 | 6 |
| 28 | 13 | 11 | 10 | 16 | 12 |
| 29 | 6 | 4 | 14 | 13 | 25 |
| 30 | 29 | 22 | 9 | 1 | 1 |
| 31 | 1 | 1 | 3 | 6 | 51 |
| 32 | 2 | 2 | 6 | 4 | 48 |
| 33 | 2 | 4 | 6 | 12 | 38 |
| 34 | 2 | 2 | 3 | 15 | 40 |
| 35 | 1 | 1 | 8 | 18 | 34 |

**Table 2. Weight Value Matrix**

| Matrix | Weight Value |
|---|---|
| W1,1 | 0.223551917 |
| W2,2 | 0.215036254 |
| W3,3 | 0.214898867 |
| W4,4 | 0.124163438 |
| W5,5 | 0.222349524 |
| SUM | 1 |

The original data matrix must be normalized using the formula in the second step of the TOPSIS approach, and the result is shown in Table 3.

**Table 3. Normalized decision matrix from the questionnaire**

| Factor No. | Irrelevant | Less Relevant | Quite Relevant | More Relevant | Very Relevant |
|---|---|---|---|---|---|
| 1 | 0.1144 | 0.1685 | 0.2777 | 0.0515 | 0.0192 |
| 2 | 0.1240 | 0.3172 | 0.1091 | 0.0343 | 0.0383 |
| 3 | 0.0572 | 0.1685 | 0.2182 | 0.1888 | 0.0575 |
| 4 | 0.1526 | 0.2974 | 0.1091 | 0.0515 | 0.0192 |
| 5 | 0.0381 | 0.2181 | 0.2579 | 0.1030 | 0.0192 |
| 6 | 0.3051 | 0.1983 | 0.0694 | 0.0343 | 0.0096 |
| 7 | 0.2479 | 0.2280 | 0.0595 | 0.0858 | 0.0192 |
| 8 | 0.2861 | 0.2379 | 0.0397 | 0.0515 | 0.0096 |
| 9 | 0.1240 | 0.2082 | 0.2579 | 0.0172 | 0.0096 |
| 10 | 0.3623 | 0.1586 | 0.0298 | 0.0515 | 0.0192 |
| 11 | 0.0954 | 0.1190 | 0.3571 | 0.0515 | 0.0096 |
| 12 | 0.0572 | 0.0991 | 0.2777 | 0.2060 | 0.0575 |
| 13 | 0.1144 | 0.2577 | 0.1587 | 0.1030 | 0.0192 |
| 14 | 0.3528 | 0.1983 | 0.0198 | 0.0172 | 0.0192 |
| 15 | 0.1907 | 0.1586 | 0.1785 | 0.1030 | 0.0192 |
| 16 | 0.0381 | 0.0397 | 0.1190 | 0.3777 | 0.1917 |
| 17 | 0.1335 | 0.1190 | 0.2579 | 0.1373 | 0.0192 |
| 18 | 0.1907 | 0.1784 | 0.0893 | 0.1373 | 0.0671 |
| 19 | 0.0381 | 0.0793 | 0.1984 | 0.3090 | 0.1150 |
| 20 | 0.0191 | 0.0694 | 0.2182 | 0.3605 | 0.0959 |
| 21 | 0.1049 | 0.1586 | 0.1785 | 0.1717 | 0.0671 |
| 22 | 0.2384 | 0.2280 | 0.0992 | 0.0515 | 0.0096 |
| 23 | 0.1812 | 0.1983 | 0.0992 | 0.1373 | 0.0479 |
| 24 | 0.2384 | 0.0991 | 0.0794 | 0.1888 | 0.0767 |
| 25 | 0.1907 | 0.1586 | 0.1785 | 0.0858 | 0.0288 |
| 26 | 0.1526 | 0.1190 | 0.2976 | 0.0515 | 0.0096 |
| 27 | 0.0572 | 0.2181 | 0.1984 | 0.1373 | 0.0575 |
| 28 | 0.1240 | 0.1090 | 0.0992 | 0.2747 | 0.1150 |
| 29 | 0.0572 | 0.0397 | 0.1389 | 0.2232 | 0.2397 |
| 30 | 0.2765 | 0.2181 | 0.0893 | 0.0172 | 0.0096 |
| 31 | 0.0095 | 0.0099 | 0.0298 | 0.1030 | 0.4889 |
| 32 | 0.0191 | 0.0198 | 0.0595 | 0.0687 | 0.4602 |
| 33 | 0.0191 | 0.0397 | 0.0595 | 0.2060 | 0.3643 |
| 34 | 0.0191 | 0.0198 | 0.0298 | 0.2575 | 0.3835 |
| 35 | 0.0095 | 0.0099 | 0.0794 | 0.3090 | 0.3259 |

The weighted normalized matrix was then computed by multiplying each normalized matrix value in Table 3 by its weight. Table 2 displays the computed weight value. The weighted normalized decision matrix from the third step of the TOPSIS approach is shown in Table 4.

**Table 4. Weighted normalized decision matrix**

| Factor No. | Irrelevant | Less Relevant | Quite Relevant | More Relevant | Very Relevant |
|---|---|---|---|---|---|
| 1 | 0.3069 | 0.6160 | 1.6712 | 0.0192 | 0.0085 |
| 2 | 0.3602 | 2.1827 | 0.2579 | 0.0085 | 0.0341 |
| 3 | 0.0767 | 0.6160 | 1.0317 | 0.2579 | 0.0767 |
| 4 | 0.5457 | 1.9184 | 0.2579 | 0.0192 | 0.0085 |
| 5 | 0.0341 | 1.0317 | 1.4409 | 0.0767 | 0.0085 |
| 6 | 2.1827 | 0.8526 | 0.1044 | 0.0085 | 0.0021 |
| 7 | 1.4409 | 1.1276 | 0.0767 | 0.0533 | 0.0085 |
| 8 | 1.9184 | 1.2278 | 0.0341 | 0.0192 | 0.0021 |
| 9 | 0.3602 | 0.9400 | 1.4409 | 0.0021 | 0.0021 |
| 10 | 3.0780 | 0.5457 | 0.0192 | 0.0192 | 0.0085 |
| 11 | 0.2132 | 0.3069 | 2.7625 | 0.0192 | 0.0021 |
| 12 | 0.0767 | 0.2132 | 1.6712 | 0.3069 | 0.0767 |
| 13 | 0.3069 | 1.4409 | 0.5457 | 0.0767 | 0.0085 |
| 14 | 2.9181 | 0.8526 | 0.0085 | 0.0021 | 0.0085 |
| 15 | 0.8526 | 0.5457 | 0.6906 | 0.0767 | 0.0085 |
| 16 | 0.0341 | 0.0341 | 0.3069 | 1.0317 | 0.8526 |
| 17 | 0.4178 | 0.3069 | 1.4409 | 0.1364 | 0.0085 |
| 18 | 0.8526 | 0.6906 | 0.1727 | 0.1364 | 0.1044 |
| 19 | 0.0341 | 0.1364 | 0.8526 | 0.6906 | 0.3069 |
| 20 | 0.0085 | 0.1044 | 1.0317 | 0.9400 | 0.2132 |
| 21 | 0.2579 | 0.5457 | 0.6906 | 0.2132 | 0.1044 |
| 22 | 1.3322 | 1.1276 | 0.2132 | 0.0192 | 0.0021 |
| 23 | 0.7695 | 0.8526 | 0.2132 | 0.1364 | 0.0533 |
| 24 | 1.3322 | 0.2132 | 0.1364 | 0.2579 | 0.1364 |
| 25 | 0.8526 | 0.5457 | 0.6906 | 0.0533 | 0.0192 |
| 26 | 0.5457 | 0.3069 | 1.9184 | 0.0192 | 0.0021 |
| 27 | 0.0767 | 1.0317 | 0.8526 | 0.1364 | 0.0767 |
| 28 | 0.3602 | 0.2579 | 0.2132 | 0.5457 | 0.3069 |
| 29 | 0.0767 | 0.0341 | 0.4178 | 0.3602 | 1.3322 |
| 30 | 1.7927 | 1.0317 | 0.1727 | 0.0021 | 0.0021 |
| 31 | 0.0021 | 0.0021 | 0.0192 | 0.0767 | 5.5442 |
| 32 | 0.0085 | 0.0085 | 0.0767 | 0.0341 | 4.9112 |
| 33 | 0.0085 | 0.0341 | 0.0767 | 0.3069 | 3.0780 |
| 34 | 0.0085 | 0.0085 | 0.0192 | 0.4796 | 3.4105 |
| 35 | 0.0021 | 0.0021 | 0.1364 | 0.6906 | 2.4641 |

Table 5 discovers the max and min values or the positive ideal (A*) and negative ideal (A–) solutions of each column in Table 5. Using step 6 of the TOPSIS technique, we estimated relative closeness to the ideal solution after obtaining the value of the separation measure. Then, we assigned a ranking to each significant failure factor for ERP system adoption. Table 6 shows the final ranking of the critical failure factors.

**Table 5. Max and min value of weighted normalized decision matrix**

| **Positive ideal (A*) and Negative ideal (A–)** | | | | | |
|---|---|---|---|---|---|
| Max | 3.0780 | 2.1827 | 2.7625 | 1.0317 | 5.5442 |
| Min | 0.0021 | 0.0021 | 0.0085 | 0.0021 | 0.00213 |

**Table 6. Final ranking of the critical failure factors of ERP Implementation**

| **Sort Cli** | **Ranked by weight** | **Factor No.** |
|---|---|---|
| 0.538002031 | 1 | 31 |
| 0.507182149 | 2 | 32 |
| 0.40054027 | 3 | 34 |
| 0.369395481 | 4 | 33 |
| 0.325554611 | 5 | 10 |
| 0.321526792 | 6 | 14 |
| 0.315932359 | 7 | 35 |
| 0.296517565 | 8 | 11 |
| 0.266908224 | 9 | 6 |
| 0.261115054 | 10 | 8 |
| 0.248853074 | 11 | 2 |
| 0.243446646 | 12 | 30 |
| 0.235823937 | 13 | 26 |
| 0.231475637 | 14 | 4 |
| 0.218845144 | 15 | 7 |
| 0.215244776 | 16 | 1 |
| 0.212247225 | 17 | 22 |
| 0.211646943 | 18 | 9 |
| 0.210450992 | 19 | 5 |
| 0.203732146 | 20 | 12 |
| 0.190688324 | 21 | 29 |
| 0.189930982 | 22 | 13 |
| 0.187621187 | 23 | 17 |
| 0.1745432 | 24 | 16 |
| 0.173183596 | 25 | 20 |
| 0.173099768 | 26 | 24 |
| 0.16723434 | 27 | 27 |
| 0.156186199 | 28 | 15 |
| 0.15617675 | 29 | 25 |
| 0.154471463 | 30 | 3 |
| 0.14941795 | 31 | 23 |
| 0.145695239 | 32 | 19 |
| 0.143988089 | 33 | 18 |
| 0.122531939 | 34 | 21 |
| 0.105076908 | 35 | 28 |

**Table 7. Six of the most important critical failure factors in ERP**

| No. of Factors | Critical Failure Factors | Relative closeness (RCi*) | Rank |
|---|---|---|---|
| 31 | Lack of understanding of the organization's business processes | 0.53800 | 1 |
| 32 | Bad business process reengineering | 0.50718 | 2 |
| 34 | High complexity of the system | 0.40054 | 3 |
| 33 | Too much system customization | 0.36940 | 4 |
| 10 | Vendors conflict | 0.32555 | 5 |
| 14 | Cost overruns | 0.32153 | 6 |

Table 7 provides the first six final rankings of the 35 important failure criteria for ERP system adoption based on 62 firm respondents. The most significant factors influencing ERP implementation failure are (31) lack of understanding of the organization's business processes, (32) bad business process reengineering, (34) high complexity of the system, (33) too much system customization, (10) conflicts between organization and vendors and (14) project cost overruns.

The first factor that most influences the failure of ERP implementation in Company XYZ is a lack of understanding of the organization's business processes. Understanding a company's business processes is the most important thing in designing a system, especially an ERP system because these business processes will be implemented into the system (Alshamrani and Bahattab 2015). In the requirements analysis phase, business analysts should be able to get detailed requirements and confirm back to the user until the testing phase (Kramer 2018). This finding contradicts (Amid et al. 2012) who revealed that a lack of understanding company's business process is not found in the first 31 rankings of 47 Critical Failure Factors of ERP implementation in Iranian Industries.

The second most influential factor is bad business process reengineering. ERP has business process best practices that companies can implement in terms of production, maintenance, logistics, accounting, etc (Jamil and Qayyum 2019; Yadav et al. 2020). Thus, in ERP implementation, appropriate business process reengineering must be carried out, either following ERP best practices or following the company's business processes by customizing programs (Ghayas et al. 2022). This finding aligns with (Yadav et al. 2020) who found that poor business process reengineering is very influential on the failure of ERP implementation and is ranked in the top ten.

The third most influential is the high complexity of the system. XYZ company has a wide range of business complexities with several different business lines, so the ERP system implemented is also quite complex with various business scenarios. Complex systems must be balanced with the ability of the operating user (Matende and Ogao 2013). This finding aligns with (Amid et al. 2012) who found that most of the project managers in Iranian Industries mentioned high system complexity as the sixth leading cause of ERP implementation failure.

Furthermore, the fourth most influential factor in the failure of ERP implementation at Company XYZ is too much system customization. Too much customization in the ERP system can cause bugs that make it difficult for users and generate incorrect reports (Ali and Miller 2017). According to several studies, a good ERP system that runs smoothly is a system that doesn't do a lot of customization and follows the best practices of the system (Amid et al. 2012; Yadav et al. 2020; Prasetyo et al. 2019; Xue et al. 2005). This finding aligns with (Huang et al. 2019) who found that minimum customization or avoiding customizations indicates the success of an organization in implementing an ERP system.

Then the fifth most influential factor of ERP implementation failure at Company XYZ is vendors' conflict. The vendor chosen when implementing ERP is very important because the vendor brings in resources, products, and knowledge of the customer's business processes (Elragal and Haddara 2013). Vendor assessment before the project is carried out can help vendor selection, it is better if the vendor has already implemented the program in several similar businesses (Prasetyo et al. 2019). This finding aligns with (Chakravorty et al. 2016) who found that failure of the company's ERP implementation can result from a mistake in vendor selection.

The sixth most influential factor is the cost overrun. Good project planning should describe in detail all project components including costs that will occur in the future (Jaeger et al. 2020). Likewise, project boundaries must also be defined so that the project can be executed, the project objectives are achieved, and no cost overrun occurs (Amid et al. 2012; Ghayas et al. 2022). This finding contradicts (Huang et al. 2019) who revealed that cost overrun does not have an impact on the failure of ERP implementation, but it is a failure of the project manager in project management.

Other factors are also quite influential in the failure of ERP implementation in Company XYZ, but improvements will be made to the top six factors first to be able to overcome implementation failures in the next phase. By identifying the critical factors that affect ERP implementation failure at Company XYZ, several recommendations can be suggested for companies who want to (re-)implement ERP. To avoid repeated failures in the future, companies can conduct a deeper analysis of the existing business processes and processing business units to determine more appropriate business process reengineering for ERP implementation. The involvement of consultants and implementing teams in conducting in-depth analysis is also needed to better understand what users need (Prasetyo et al. 2019). In this case, the business processes and processing business unit have complex processes so in the previous implementation there was a lot of customization on the SAP application, which caused the use of the ERP system to be less than optimal. In the future, after an in-depth analysis, it is necessary to design an ERP system that is more in line with current business processes and can reduce system complexity. From the factors in the project management category, there were conflicts during ERP implementation and cost overruns. In the subsequent implementation, the project manager's role is needed to avoid these things.

In mining sector companies that have many business units, it is essential to pay attention to the factors that cause ERP implementation failure. Lack of process vision and deployment process in ERP business process can be a major factor of implementation failure. Thus, for ERP implementation in companies that have many business units, it is better to have subject matter experts who know the company's overall business processes and understand how business processes in ERP can be carried out so that business process reengineering can be carried out accordingly.

## Conclusion

In this work, critical failure factors of ERP implementation in Company XYZ were identified using a survey and then processed with the TOPSIS method. These factors are categorized into several types, and the results of this study indicate that the process, technical, and project management categories are the main causes of the failure of ERP implementation in Company XYZ. The first factor that most influences the failure of ERP implementation in Company XYZ is a lack of understanding of the organization's business processes, followed by bad business process reengineering in second place, high complexity of the system in third place, too much system customization in fourth place, then vendors conflict in fifth place, and lastly in sixth place is cost overrun. It can also be seen that implementation failure can occur in only one of the company's business units. Even though the same consultant, vendor, implementation time, top management, and implementation team are used, implementation failures can still occur.

This research makes four contributions, 1) it provides in-depth insight into critical failure factors of ERP implementation in multi-business area companies, 2) it illustrates how a TOPSIS methodology is used to rank critical failure factors of ERP implementation, 3) it makes recommendations to the company who wants to implement ERP system to concern in failure factors that often cause implementation failure, and 4) it provides an extended model for company who wants to evaluate critical failure factors of ERP Implementation.

This research is limited to evaluating implementation failures that occurred in one mining company, in the future it can be developed to evaluate system implementation failures in many mining companies in Indonesia. Further research also can continue how ERP implementation is carried out in companies that have many business units with different lines, what methods should be used, and what tips need to be implemented. The ranking method used is TOPSIS because it is relatively easy and accurate to use.

Respondents are currently still in the internal company, in the future, it can be developed for external companies such as vendors, consultants, and auditors.

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# Appendix

**Critical Failure Factors (Amid et al. 2012)**

| Categories | No. | Factor Name | Factor Description |
|---|---|---|---|
| Organizational (OR) | 1 | Government organization structure | Rigid and highly hierarchical organization structure of government |
| | 2 | Internal conflicts | There is an internal conflict of interest over the implementation of the ERP system |
| | 3 | Inflexible company | Organizations have difficulty adjusting to changing business processes |
| | 4 | Rigid company culture | The organizational culture is very rigid and difficult to accept new conditions |
| | 5 | Misfit of ERP system to company's structure | ERP system incompatibility with organizational structure |
| | 6 | Wrong design business strategies | The definition of business strategy is not fit so the objectives of ERP implementation are not on target |
| | 7 | Poor strategic objectives | Organizational strategic goals that are not good among employees |
| | 8 | Unstable managerial positions | Changes in managerial positions are quite fast and massive |
| Project Management (PM) | 9 | Consultants conflict | There was conflict between consultants during the implementation phase |
| | 10 | Vendors conflict | There was a conflict with the vendor/ ERP product during the implementation phase |
| | 11 | Lack of project team | Inexperienced ERP implementation project team |
| | 12 | Bad project management | Poor project management during implementation |
| | 13 | Bad risk management | Poor risk management during implementation |
| | 14 | Cost overruns | The project cost exceeds the specified budget |
| | 15 | Timeline delays | The implementation timeline does not follow the planning |
| | 16 | Lack of project boundaries | Project boundaries are not well-defined |
| Human Resources (HR) | 17 | Rigid employee's mindset | Employees' minds are not flexible so they cannot accept changes in business processes |
| | 18 | Lack of training and knowledge transfer | Lack of training and knowledge transfer sessions between employees |
| | 19 | Lack of employee involvement | Lack of training and knowledge transfer sessions during the implementation and transfer of employee positions |
| | 20 | Poor communication | Lack of clear communication regarding understanding of the ERP system |
| | 21 | Poor change management | Lack of change management strategy during the transition to business process changes using the ERP system |

| Categories | No. | Factor Name | Factor Description |
|---|---|---|---|
| | 22 | Lack of employee motivation | Lack of employee motivation to play an active role in supporting ERP implementation |
| | 23 | Incompetence key users | Lack of competency of key users, so the process of knowledge transfer to end users is not effective |
| | 24 | Baseless expectations | User expectations are too high for the ERP system |
| Managerial (MG) | 25 | ERP readiness assessment missed | An ERP readiness assessment is not carried out before implementation |
| | 26 | No performance measurement system | Project Manager does not run a performance measurement system |
| | 27 | No long-term planning | There is no long-term plan for the function of the ERP system |
| | 28 | Lack of top managerial support | Lack of support from top management for all activities related to the ERP system |
| Vendor and Consultant (VC) | 29 | Incompetence Consultant | ERP implementor consultants are less competent/experienced |
| | 30 | Unprofessional vendors | |
| Processes (PR) | 31 | Lack of understanding of the organization's business processes | Vendors/ ERP products are less professional and experienced |
| | 32 | Bad business process reengineering | Business process reengineering does not align with best practice ERP processes |
| Technical (TC) | 33 | Too much system customization | Too many program customizations have caused a lot of bugs in the system |
| | 34 | The high complexity of the system | High complexity of the system because it forces to follow the company's business processes |
| | 35 | Inaccurate data | The data entered into the system is inaccurate resulting in incorrect reports |

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# Development of Integrated Warehouse Application for Retail Business with Multi-Echelon Demand using Open-source ERP System

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## Abstract

*The Integrated Warehouse Application (IWA) is a platform that combines inventory management, order management, warehouse operations, shipping, logistics, and reporting and analysis. It helps users manage their inventory to meet supply and demand requirements. Although many large companies use IWA to increase operational efficiency, its complexity, technology, and customization requirements make it too expensive for small and medium-sized enterprises (SMEs). Our research centers on small and medium-sized enterprises (SMEs) operating in the retail industry. Fast and precise order processing is crucial for satisfying and retaining customers. Therefore, we aim to discover strategies that cater to the diverse demands of different retail levels. The method for this study was conducted in four stages. The first stage involved preparation and planning by mapping out the initial process and identifying the relevant system based on the existing condition. The second stage focused on gathering data from the previous system through process and analysis. The third stage involved designing and developing the system, including prototyping, confirming, and adjusting it. Finally, the system was delivered in the fourth stage, and training was provided for each user. To create the system interface, we utilized an open-source ERP system called Odoo, which helped develop the IWA. Our findings show that implementing an integrated warehouse inventory system like the one provided by Odoo can offer real-time visibility into inventory levels, orders, and shipments. Automating manual processes enhances speed and accuracy, which improves customer service and business performance.*

**Keywords:** Integrated Warehouse Application; Odoo; Retail Business; Retail; SMEs

## Introduction

Small and Medium Enterprises (SMEs) play a vital role in the global economy (Alaskari et al. 2021). Nearly all businesses (99%) in Indonesia fall under micro, small, and medium enterprises (MSME). With 816,000 SMEs contributing to 27% of the GDP, they significantly contribute to the country's economy (ILO-PROMISE IMPACT project 2019). Additionally, small and medium retail businesses make up 60% - 70% of the Indonesian retail market and have the potential to proliferate (Hasegawa

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and Tani 2022). Some SMEs in retail businesses have branches in various locations or function as distribution centers with multiple stock points. However, these retailers face challenges managing inventory, balancing supply and demand, and simultaneously overseeing retail and warehouse operations (Quona Capital 2021). These challenges in SMEs in retail business can be handled using Information and communication technologies (ICT) that can assist through Enterprise and Resource Planning (ERP).

In modern business, the needs of ERP are crucial. Businesses use ERP software to manage various business activities, such as accounting, procurement, project management, risk management, compliance, and supply chain operations. Additionally, the ERP suite includes Enterprise Performance Management software that assists with financial planning, budgeting, forecasting, and reporting (Yulianto et al. 2020). ERP systems can be both complex and costly. The price is determined by factors such as their level of customization, implementation, acquisition, long-term support, and overall complexity (Malhotra and Temponi 2010). Small and medium-sized retail businesses need help to become more flexible and adaptable (AlMuhayfith and Shaiti 2020).

Studies have shown that implementing an ERP system in SMEs can bring numerous benefits (Estébanez 2021; Rupčić 2021; Tambovcevs and Tambovceva 2022). This solution can enhance business effectiveness, improve functionality, and lead to satisfied users. However, it may also come with increased implementation costs, complexity, and expenses for upgrades. In practice, companies often choose to customize their ERP system and adapt their business processes accordingly (Hansen et al. 2023; Hustad and Stensholt 2023). This also applies to SME businesses such as retail businesses. Small and medium-sized retailers need to adopt an ERP system. It keeps the balance of supply, demand, and distribution to maintain the availability of items.

In the retail industry, an ERP system should be capable of managing inventory, generating analytics and reports, managing customer and vendor relationships, fulfilling orders, and facilitating point-of-sale transactions (Davyn Limited 2023). Small and medium-sized retail businesses can benefit from using an Open-source ERP system that is customizable, easy to maintain, and cost-effective. This solution is ideal for SMEs to streamline their operations and maintain their business while maintaining their budget.

In the past, various studies have utilized Open-source ERP systems in the retail industry. Suryo et al. (2021) implement Odoo modules, such as sales, purchase, accounting, point of sale, CRM, and marketing, for a food retail business in Jakarta. Navalina et al. (2021) concentrated on an accounting information system to enhance customer service and satisfaction while considering demand in retail. Alghazali and Ageeli (2020) focused on inventory management within a retail company, considering the relationship between information and effective decision-making processes.

Other studies such as Antari et al. (2014); Bakhri (2019); Retnasari (2021); Suryantoro (2021); and Tongsuksai et al. (2022) also have used ERP systems to manage retail needs in small and medium-sized enterprises (SMEs), in most cases, the inventory being managed is for retail purposes, and the single source demand comes from retail (shops). It gets more complicated when there are multiple sources of demand, such as a Distribution Center (DC) that serves as a warehouse, stocks retail located in different areas (branches) and serves customers directly. These retail branches also have their inventory that needs to be managed. This study takes into account this added complexity when implementing its Open-source ERP system.

The goal of this research is to create an Open-source ERP System that will benefit small and medium-sized retail businesses. This software is called Integrated Warehouse Application (IWA). Unlike previous studies, our research focuses on the various sources of demand, including multi-echelon demand from Distribution Centers, individual customers, and customers who visit the retail branch shops. It is important because the software will connect the Distribution Center (DC) with customers and retailers, improving the efficiency of ordering, planning, and distribution. The purpose of using an Open-source ERP system for SMEs in Retail business is to gain flexibility in business with lower cost. This study is divided into four sections: Section 2 outlines the methodology, Section 3 presents the results, Section 4 is discussion, and Section 5 provides conclusions.

## Methodology

Dunaway (2012) explains that ERP systems use a flexible company-driven approach to implementation that can be tailored to meet the unique requirements of each project. The current study also utilizes a simplified company-driven methodology outlined in Figure 1 and consists of four stages: planning and preparation, analysis and processing, design and production, and delivery and training. These four phases have been modified and improved upon by (Ibrahim et al. 2022).

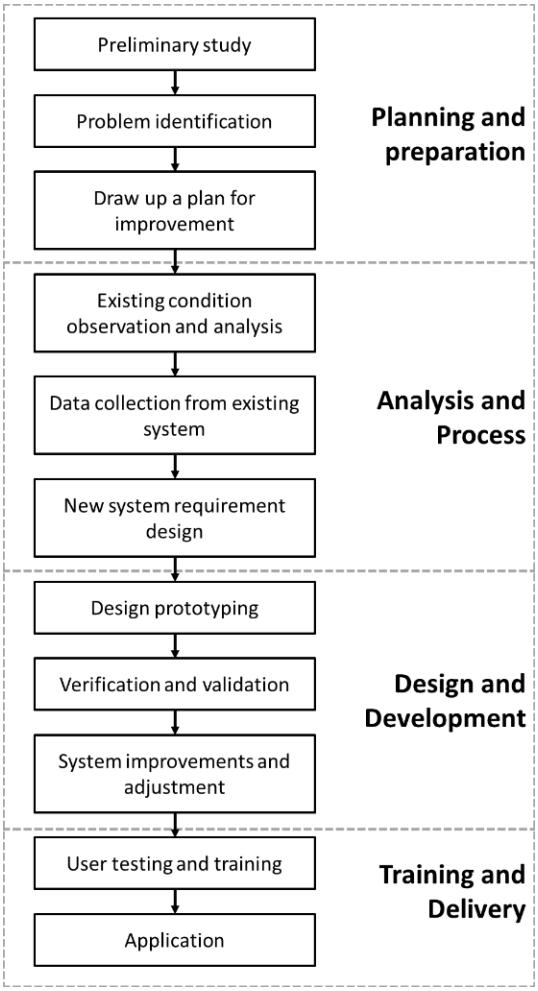


**Figure 1. Flowchart for Research Method**

### *Preparation and Planning System*

In the initial phase, there are three tasks to be completed. The first task involves conducting a preliminary study, which includes a literature review and field research. The literature review focuses on ERP and information systems that are relevant to the retail industry. The field research is conducted to validate the requirements of retail businesses and lays the foundation for system development. The second step is to identify the problem, which involves analyzing current conditions, collecting initial data from the current information system's output, comparing the data with the distribution center's needs, and designing new system requirements. The last step in this phase is to create an improvement plan. This involves brainstorming ideas, conducting literature reviews to establish the base of the problem, and mapping the idea into a written plan. This plan outlines the scenario for improving the system.

### *Process and Analysis*

During the second stage, process, and analysis, we focused on analyzing the existing condition of the object of study by observing its working sequence. The object of study already had their warehouse system called ePOS. ePOS, also known as electronic point of sale, is a computerized system used in retail shops to record sales. It includes functionalities such as payment processing, customer interaction, and data storage. However, the current system has a problem - the information is not connected to the head office, which is the distribution center. As a result, the product information, including the order needs from retail, stock, inventory, and retail orders, is not connected to the DC. Retail needs to manually update the stocks and sales information to the distribution center daily by extracting the sales data and sending it to the DC. Only after that can the DC decide whether to add more stock to the existing retail stock.

In the second stage, the focus is on gathering data from the current ePOS system. This is necessary to develop a new information system for retail businesses. The data collected will include sales data, product data, sales documents, stock data, company workflow processes, and the role of each department in the company. Providing these details is essential to developing the requirements for the new system development process.

### *Design and Development*

The third phase of the project involves design and development, which consists of three tasks. The first task is to create a prototype design using an Open-source ERP system application. Once the initial design is completed, the second task is to confirm it with users by conducting forum group discussions and interviews with each department. If any adjustments are needed, the system will be fixed and adapted to meet the user's needs.

### *Delivery and Training*

Once the information system is fully developed, it enters the delivery and training stage. The IT department responsible for the system receives training to maintain the system for later. Next, the integrated system, which combines various departments such as distribution center (DC), accounting, purchasing, retail, and warehouse, is handed over to the user for testing and training. Once the system has been adjusted according to user feedback, it requires confirmation from the operation manager before it can be connected to the company server and used as an integrated warehouse application (IWA).

## Results and Discussion

This sub-chapter will explain the results of the analysis and creation of an information system using an Open-source ERP system as follows:

### *Preliminary Studies*

To conduct our research, we need to conduct preliminary studies which consist of understanding the object business and then understanding the current state of the ePOS system as follows.

*Scope of study*

This study focuses on a retail chain with a single distribution center (DC) and four retail locations. Demands for products come from both the DC and the retail stores, which are located in Surabaya, Lumajang, Tuban, and Bojonegoro. Customers have the option to purchase products directly from either the DC or retail stores. Although the number of customers varies, demands are received daily from both the DC and retail locations. For further information, see Table 1.

**Table 1. Scope of the Object of Study**

| No | Information | DC | Retail |
|---|---|---|---|
| 1 | Demand | Individual customers, retail chains | Individual customer |
| 2 | Number of employees | 12 /DC | 2~4 /retail |
| 3 | Job responsibility (department) | Accounting, procurement, purchasing, warehouse and delivery, operation manager, IT department, retail manager | Retail manager, inventory manager, sales (cashier) |
| 4 | Demand's arrival | Daily | Daily |
| 5 | Time for delivery of goods to retail | Twice a week (Tuesday and Thursday) | - |
| 6 | Update stock | Daily (manually after getting the information from retails) | Daily (update the stock manually and send the emails to DC) |

*Current state assessment*

Once the problems in the research object are identified, the next step is to assess the research object's current state or existing state. The initial plan for the new information system involves integrating the distribution center - including the accounting, purchasing, DC staff (admin), warehouse, and delivery departments - with retail operations. This new system is called an Integrated Warehouse Application (IWA). To clarify the current situation in the industry, we analyzed two primary locations: distribution centers which can be seen in Table 2, and retail which can be seen in Table 3.

**Table 2. Distribution Center Existing Business Process**

| No | Activity | Actor | Output Document |
|---|---|---|---|
| 1 | Making orders to the supplier | Procurement staff | Purchase Order |
| 2 | Re-confirm the order | Purchasing staff | Item packing list documents |
| 3 | Contact supplier for product confirmation | Purchasing staff | - |
| 4 | Receiving; Checking arriving product | DC Staff | Good Receipt Note |
| 5 | Making payment | Accountant | Payment notes |
| 6 | Input new inventory data | DC Staff | New product document |
| 7 | Make a shipment note to the retail | Accountant | Remittance Note |
| 8 | Creating data and returning goods to the supplier | Accountant | Return Note |
| 9 | Stock updates | Procurement staff | Documentation of product |

The DC being observed serves as the primary warehouse for multiple retailers both inside and outside the city. It also serves as a retail which sells products directly to customers. Despite having a vast inventory of around 3,500 items, the roles and responsibilities of employees are not clearly defined causing conflicting tasks. When employees are assigned conflicting tasks, it can become unclear what their actual assignments are.

**Table 3. Retail Existing Business Process**

| No | Activity | Actor | Output Document |
|---|---|---|---|
| 1 | Make orders to DC | Warehouse staff | Purchase Order |
| 2 | Reconfirm the order | Purchasing staff | Item List Packing Document |
| 3 | Contact DC for product confirmation | Purchasing staff | - |
| 4 | Receiving; Checking arriving product | Warehouse staff | Notes of receipt of goods |
| 5 | Input new inventory data | DC Staff | Input document goods |
| 6 | Make receipt note for DC | Cashier (accountant) | Payment notes of goods |
| 7 | Creating data and returning goods to DC | Cashier (accountant) | Return note |
| 8 | Doing stock updates | Procurement and warehouse staff | Documentation of product |

The observed object comprises retail stores located both within and outside the city has already been explained in the sub-section Scope of study, with a warehouse stock controller in the form of a DC. The DC is tasked with the crucial responsibility of determining the suppliers, number of orders, and type of goods ordered, while the retail stores are responsible for sales and stock updates. To order sales products, the retail stores place orders at the DC. In addition, they manually enter daily stock updates into the ePOS system as the information systems at retail and DC are not connected. Upon receipt of the reports from the retail stores, the DC performs manual checks before confirming the stock update process with the retail stores. Based on this information, the DC determines which products must be sent to the retail stores, with deliveries scheduled twice a week to avoid stock shortages.

### *Existing Object Condition Analysis*

Existing condition analysis is carried out by analyzing the relationship between ideal conditions based on user expectations, current conditions, and proposed solutions (Ibrahim et al. 2022). This relationship can be seen in Table 4 below.

The gap between Supplier, DC, and Retail has caused inefficiency and inflexibility. Any updates to the information in the system cannot be detected in real-time and cause delays in responses.

### *Conceptual model for the business process*

To determine the requirements for a new information system, we analyzed the existing conditions and conducted a gap analysis. Based on this, we created a conceptual model focusing on the supply chain's three elements: suppliers, distribution centers, and retail. The To-Be Business process, a conceptual model, is divided into two processes. The first business process is for issuing the products or items from DC, as shown in Figure 2. The second business process is for planning and receiving products in DC, as shown in Figure 3. The explanation is as follows:

*To-Be Business Process for issuing the Products or Items from the Distribution Center*

The product issuing process involves three parties: Retail, DC, and customers, as depicted in Figure 2. The Sales and Purchasing, Procurement, and Warehouse departments at the DC are all involved in this process. Open-source software is utilized by the system to connect all parties, resulting in increased efficiency. The real-time updates feature is the primary differentiating factor from previous conditions. Both Retail and DC can now update and track the movement of stock in and out of both parties simultaneously.

**Table 4. Gap Between Ideal, Existing, and Recommendation for DC and Retail**

| No | Activity | Ideal Condition based on User expectation | Existing Condition | Proposed Solution |
|---|---|---|---|---|
| 1 | Making orders to the supplier/ DC | Create purchase order documents in real-time through the Procurement Division. | To place an order, one must wait for a manual request for goods notes from the procurement department. | Utilize software to prepare and submit purchase order documents, allowing for real-time receipt of information. |
| 2 | Re-confirm the order | The order information and packing list are recorded and verified and can be accessed by the Purchasing Division. | Currently, gathering order information and creating packing lists is manual and not real-time, which causes delays in confirmation. | Utilize software to submit and verify orders swiftly. |
| 3 | Contact supplier/ DC for product confirmation | Direct order information is marked and confirmed and can be seen by the Purchasing Division. | The process of submitting information is currently done manually and is not linked together. | Easily submit information with the proposed software with no delays or time-consuming steps. |
| 4 | Receiving; Checking arriving product | Direct checking when the ordered goods come according to the purchase agreement | It is necessary to wait for the product receipt from the purchasing division to check the goods manually. | Use integrated software to check incoming goods and view arrival information directly. |
| 5 | Making payment | Make payments directly and or according to the goods purchase agreement | Manual payment notes can lead to number notation errors that are difficult to communicate | Prepare and submit payment receipts in real-time using software tools, which help us to integrate with related divisions. |
| 6 | Input new inventory data | Generate additional input documents for purchased goods. | Incoming goods are entered manually, requiring manual recalculations and adjustments to stock levels. | The software enables direct and real-time input of goods data into the inventory master data of the DC. |
| 7 | Make a shipment note to the retail | Create a Packing List (Packing List) of goods to be sent to the customer retail according to the request. | Using manual notes to track goods shipments results in a significant amount of time wasted on receiving and confirming orders. | By integrating software tools with the relevant divisions, packing lists can be made, and products can be delivered in real-time. |
| 8 | Creating data and return of goods returns to the supplier/ DC | Create a record of requested returns of goods to be sent directly to the supplier/ DC. | Using manual return notes can be time-consuming, leading to delays in receiving and confirming orders. | Creating return notes for products is easier with integrated software tools that allow for real-time submission to the relevant divisions. |
| 9 | Stock updates | Create and update the new stock of goods in the DC Master Data Inventory directly. | The update is a manual process that is time-consuming and does not directly update the DC inventory master data. | Utilize integrated software tools to update the inventory in real time and ensure it is properly stored and maintained. |

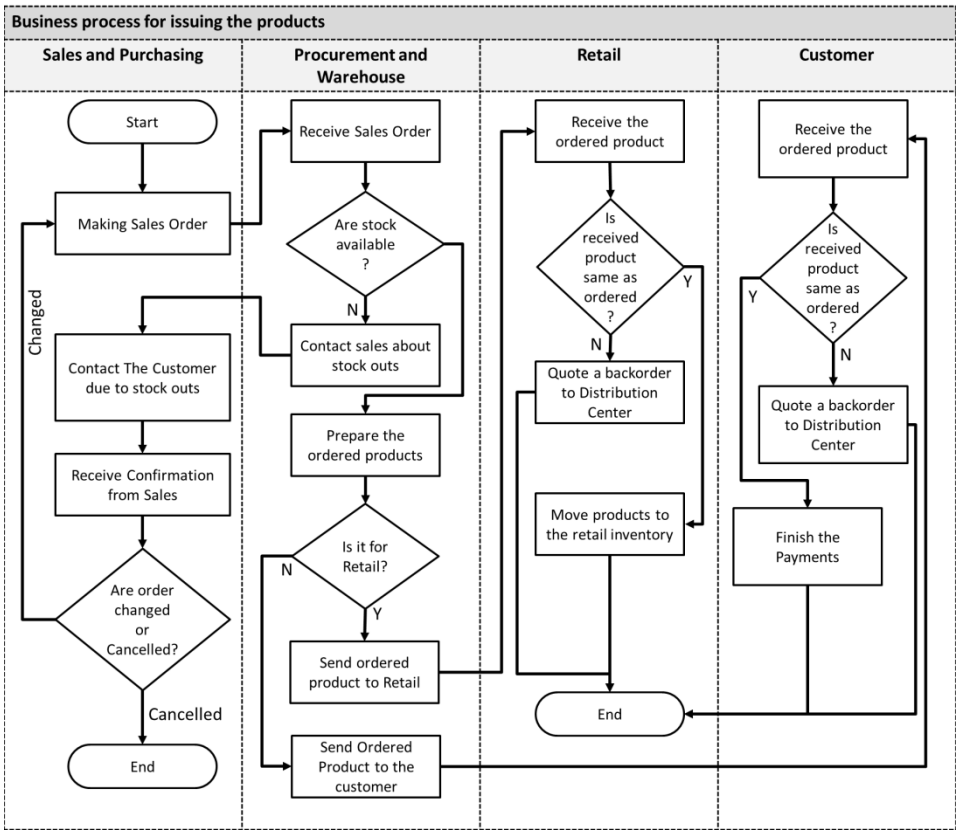


**Figure 2. To-Be Business Process for issuing the Products or Items from the Distribution Center**

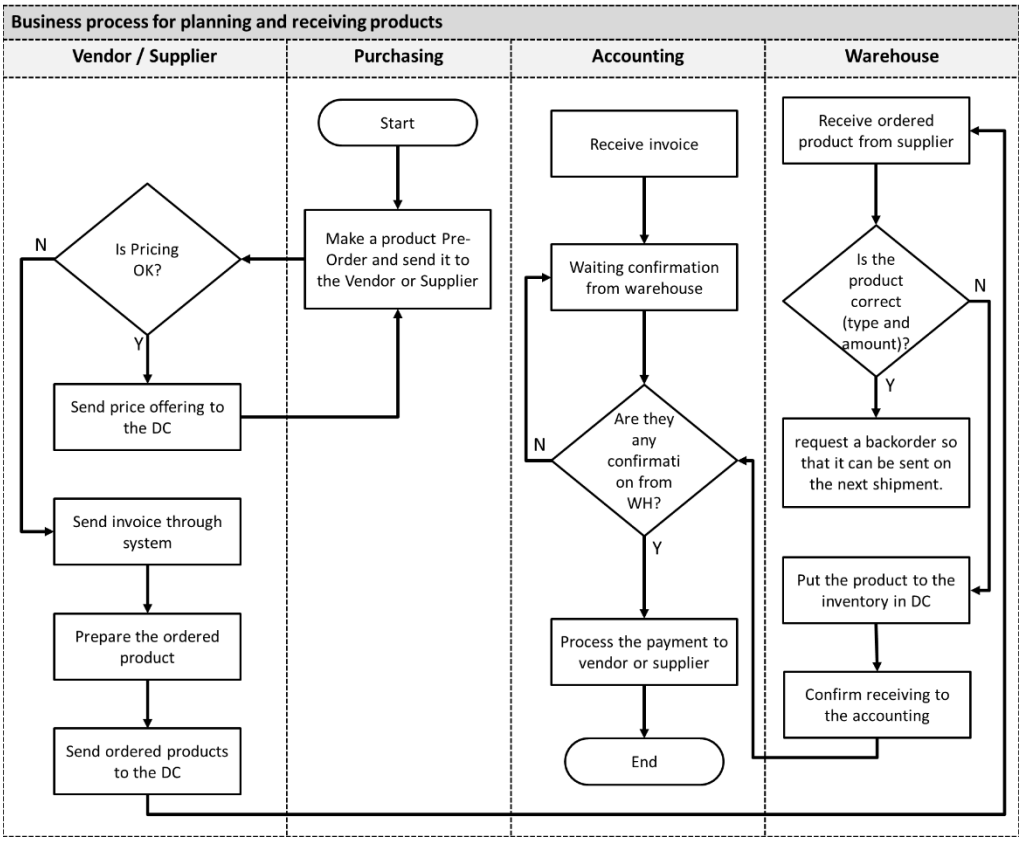


**Figure 3. To-Be Business Process for planning and receiving products in the Distribution Center**

*To-Be Business Process for planning and receiving products in the Distribution Center*

Figure 3 illustrates the process of planning and receiving the product. In the previous method, the product was planned and received manually, leading to a higher chance of errors. The purchasing department had to manually input additional products into the system after checking the received product. However, in the newly developed system, the warehouse processes the product received from the vendor and submits it to the system directly, allowing for direct input of product amount and faster payment processing by the accountant. This new system reduces manual processes and increases efficiency for each department, enabling them to work more effectively.

*Implementation of Open-source ERP System for Integrated Warehouse Application (IWA)*

To create the integrated warehouse application, we utilized the Open-source ERP system Odoo. To begin the process, we determined the number of users and modules required, as shown in Table 5, before creating the interface.

To accommodate needs in DC and retail, there are seven identified user types and four necessary modules. The user types include administration/IT support, head of accounting, purchasing department, accounting staff, head of operations, warehouse and shipping staff, and retail staff. The four modules needed are sales, inventory, purchase, and invoicing, which are specific to certain sections. Every section has control over the Module that is generated, with three types of authority: Support, Admin, and User. The Support authority is responsible for the application system, allowing the Administrator/IT Support to manage the system, add user data for login purposes, and ensure server security. The Admin status authority allows for editing, changing, and adding components within the authorized Module. Meanwhile, the user is only able to view module components. Once the user enters the system, they will be directed to the main display.

**Table 5. User Rules for the Open-source Application**

| No | User | Module | | | |
|---|---|---|---|---|---|
| | | **Sales** | **Inventory** | **Purchase** | **Invoicing** |
| 1 | Administrator/IT Support | Support | Support | Support | Support |
| 2 | Head of Accounting | Admin | Admin | Admin | Admin |
| 3 | Purchasing department | | Admin | Admin | |
| 4 | Staff Accounting | User | | | Admin |
| 5 | Head of Operational | Admin | Admin | Admin | |
| 6 | Warehouse and Delivery Staff | | User | | |
| 7 | Retail staff | | User | | |

Figure 4 displays the homepage of the application. Access to different modules is based on user authority, as detailed in Table 5. The inventory module has visibility between warehouses and facilitates the warehouse's receipt and issuance of goods to retail and direct customers, as shown in Figure 5 and Figure 6. Meanwhile, the Purchase module supports the purchase of goods from DC to vendors/suppliers, as seen in Figure 7. Figure 8 displays the product master data, which can be modified based on availability in the warehouse. It includes product name, quantity, and price. Lastly, Figure 9 depicts the sales module utilized by DC and Retail for direct customer sales.

Efficiently providing real-time information optimizes the user experience. The new system has been divided into four modules, each tailored to meet the specific needs and responsibilities of each department. In the previous system, there were gray areas in terms of responsibilities, with some jobs duplicated across departments. However, the new system eliminates redundant work by streamlining each department into its respective module and preventing overlapping tasks.

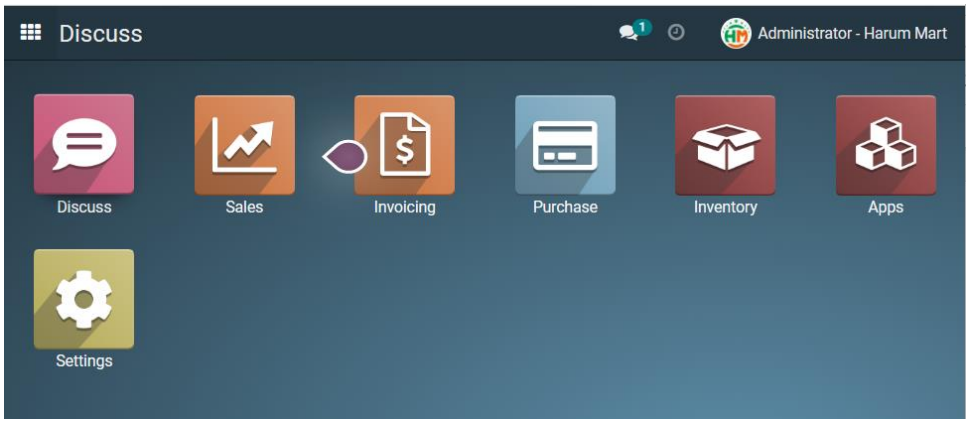


**Figure 4. Homepage Display**

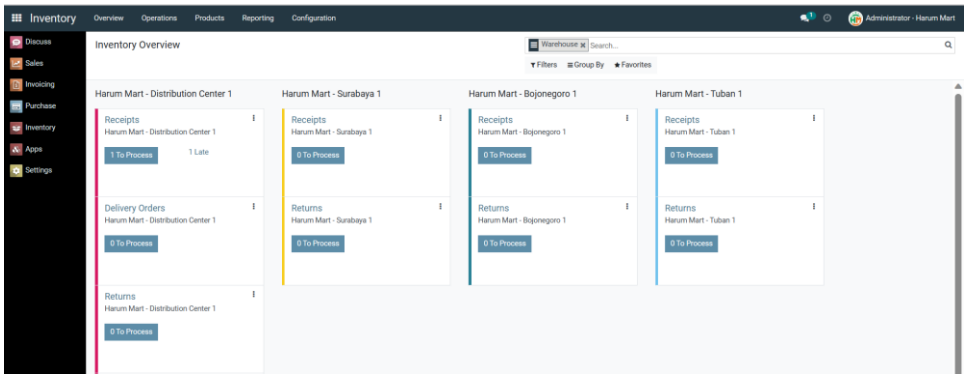


**Figure 5. Inventory Module Dashboard**

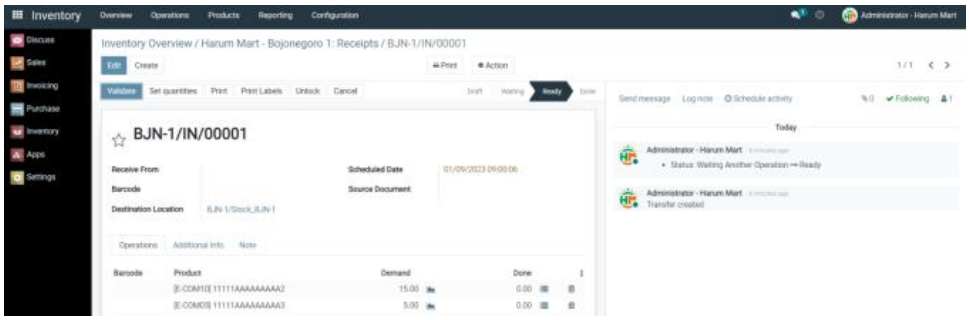


**Figure 6. Inventory Module for Product Receiving**

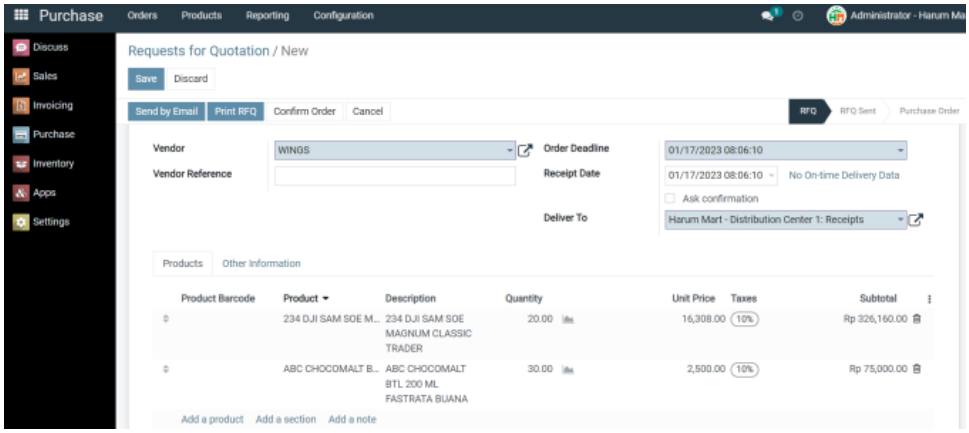


**Figure 7. Purchase Module for Product Receiving**

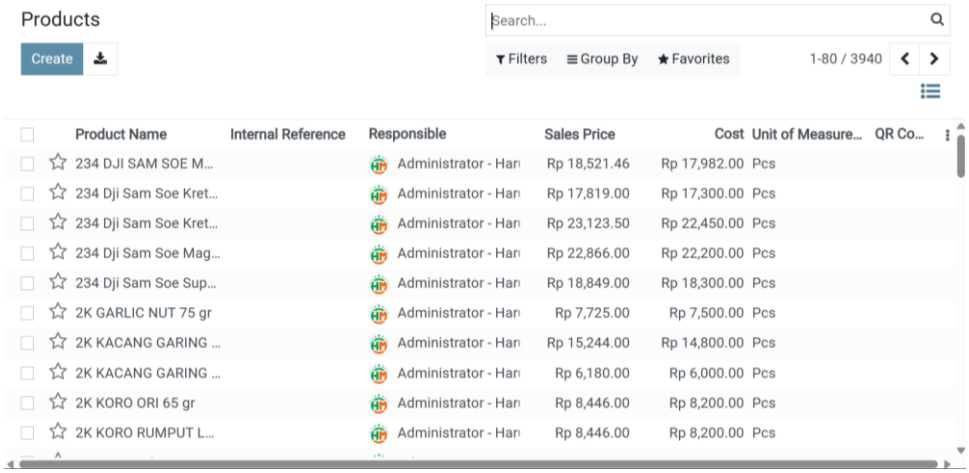


**Figure 8. Master Data Product**

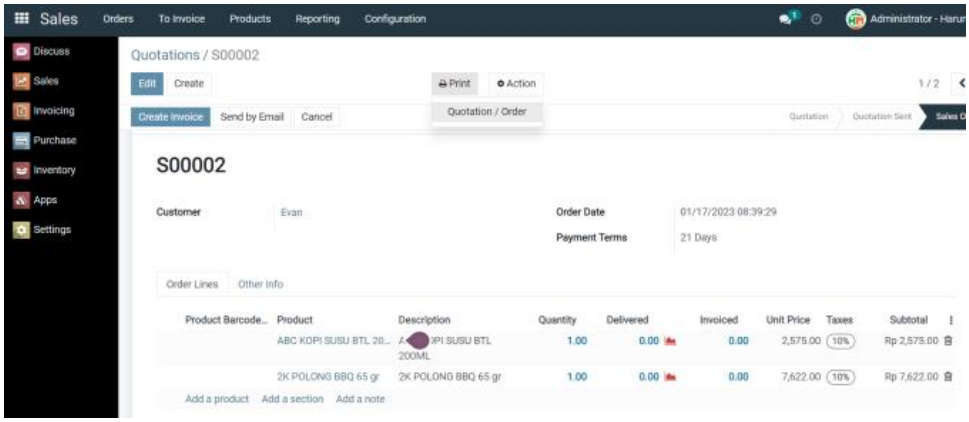


**Figure 9. Sales Module**

## Conclusion, Implication, and Recommendation

Previously, data entry for the object of study had to be done manually since there was no real-time connection between the distribution center (DC), vendors/suppliers, and retail outlets. This led to updates being delayed and the process being time-consuming. Additionally, there were often errors due to human mistakes. To address these issues and improve the real-time process, an Open-source ERP system has been successfully implemented to integrate DC and retail warehouse activities in real time. This research aims to implement the new system and connect the DC, Retail, and Vendor/Supplier by analyzing the current condition and validating it through the object.

This research has implications for our object of study. We have developed a new Integrated Warehouse Application (IWA) system that utilizes Open-Source ERP software. The IWA system provides detailed and real-time visibility of stock items across our one DC and three retail locations. Our approach is flexible and company-driven, tailored to meet your specific needs in four stages: planning and preparation, analysis and processing, design and production, and delivery and training. The new system is designed to provide real-time processes and updates throughout the entire supply chain. It enables users to make an order to the supplier/ DC, re-confirm the order, contact the supplier/ DC for product confirmation, receive and check arriving products, park payment, input new inventory data, make a shipment note to retail, create data and return of goods returns to the supplier/ DC and also stock updates. All administrative processes related to product supply from the DC to each retailer, as well as reverse logistics, are carried out in one integrated system. One key feature of the IWA system is its ability to automatically issue orders based on predefined Reorder Points. This enables more effective and efficient processes, as well as better inventory management. Moreover, as the implementation has just begun, the system provides real-time information that assists management

in making quick and accurate decisions.

IWA offers instant data updates to streamline exchange processes. However, future research could expand the system's capabilities to include retail sales at the Point of Sale (PoS). Additionally, a more flexible connection between a company's financial and inventory data is necessary for precise decision-making based on updated data patterns. This would create a comprehensive system for businesses, covering everything from procurement, finance, and inventory management to warehouse management, fulfillment, and PoS.

## Acknowledgment

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# Exploring the Relationship between Green IT Awareness and Adoption: A Case Study of IT Students in the Gaza Strip

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## Abstract

*Green IT, also known as GIT, has emerged as a crucial field in response to environmental concerns. This study focuses on assessing the level of GIT awareness and adoption among IT students at Al-Aqsa University in Gaza, as well as examining the relationship between GIT awareness and adoption. This assessment is crucial for fostering environmentally responsible technology practices and preparing future IT professionals to contribute to sustainable technological advancements. Data was collected through an online questionnaire completed by 273 participants. The questionnaire covered various aspects of GIT awareness, including understanding, environmental awareness, and e-waste awareness. The collected data was analyzed using statistical techniques such as principal component analysis, mean, and standard deviation. The results indicated that students possessed a satisfactory level of understanding of GIT concepts and the reasons for its adoption. Furthermore, the findings highlighted the significant impact of GIT awareness factors, including GIT understanding, environmental awareness, and e-waste awareness, on GIT adoption. However, it was observed that students did not consistently adhere to GIT guidelines, particularly in terms of frequent internet access and extended computer usage. Interestingly, no significant relationship was found between GIT adoption and students' academic standing. These findings provide valuable insights into the current state of GIT awareness and adoption among IT students and underscore the need for further efforts to promote sustainable computing practices.*

**Keywords**: green computing awareness, green computing adoption, e-waste, e-waste management.

## Introduction

The demand for electrical and electronic equipment (EEE) is experiencing rapid growth globally, driven by changes in modern lifestyles. This trend leads to an annual increase in global EEE consumption, resulting in a significant amount of electronic waste (e-waste) (Forti et al. 2020). In line with this, the global generation of e-waste exceeds 50 million metric tons each year, equating to an average of approximately seven kilograms of e-waste per person (Statista 2023). Moreover, the growing utilization of the Internet and social media is leading to a rise in energy consumption and electronic waste, thereby directly impacting the environment (Sriram 2022). According to Enerdata (2018), information and communication technologies (ICTs) presently contribute to approximately 5% to 9% of the overall electricity consumption. Examples of e-waste include personal computers, laptops, DVD players,

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cooling and freezing equipment, small and large electrical equipment, display screens, printers, GPS devices, IoT devices, and mobile phones. In 2019, the global production of e-waste reached approximately 53.6 million tons, and this number is projected to increase by nearly 30% by 2030 (Andeobu et al. 2021). According to the research conducted by Forti et al. (2020), out of the 53.6 million metric tons (Mt) of e-waste generated worldwide, only 17.4% was officially reported as being collected and recycled in a proper manner. Since 2014, there has been an increase of 1.8 Mt in the documented amount of e-waste, but the overall generation of e-waste has increased by 9.2 Mt. If no action is taken, it is projected that e-waste production will more than double to 120 million tons per year by 2050 (World Economic Forum 2019). These statistics emphasize the urgent need for enhanced e-waste management practices on a global scale. Implementing effective methods for collection, recycling, and disposal is crucial in order to minimize the environmental and health risks associated with e-waste, while also maximizing resource recovery and promoting a circular economy approach.

E-waste contains many dangerous chemicals, including lead, cadmium, mercury, arsenic, and cobalt (Lama et al. 2022). Additionally, reports have shown that the cost of operating computers worldwide totals $250 billion per year, with more than 85% of energy lost (Abugabah and Abubaker 2018). Green computing (GIT) aims to improve the way computer equipment is used and reduce the use of harmful materials. It includes energy-efficient computers and optimizes disposal and recycling methods. As a result, there is increasing demand for energy-saving technology that is also easy to recycle or dispose of without harming the environment. Therefore, it is the shared responsibility of all users, governments, and industrial and commercial companies to address this issue. The US government launched the first initiative, the Energy Star program, in 1992, which aimed to achieve maximum efficiency while using the least amount of energy for computer peripherals such as USBs, printers, displays, communication systems, servers, and network systems (Mohammed et al. 2015). Recognizing the awareness and adoption of GIT practices among IT students becomes crucial for nurturing a sustainable IT ecosystem. This significance arises from the substantial presence of students as users of computers and associated peripherals. In order to enhance the understanding of GIT in the Gaza Strip, this research has set forth several primary objectives. Firstly, it seeks to assess and analyze the level of student awareness regarding GIT. Secondly, the study aims to investigate the potential correlation between GIT awareness and its adoption among students. Thirdly, it intends to explore how GIT awareness influences the adoption of this technology among students. Additionally, the research will examine the role of gender in influencing students' GIT awareness and its potential impact on their adoption of GIT. Lastly, the study will assess whether the academic level of students has any significant influence on their awareness of GIT.

## Research Questions

In order to achieve the research objectives, the following questions will be addressed:

RQ1: What is the extent of students' awareness of GIT?

RQ2: How is GIT awareness related to its adoption?

RQ3: What impact does GIT awareness have on GIT adoption?

RQ4: Are there any gender-based differences in GIT awareness?

RQ5: Are there any differences in GIT awareness based on academic level?

## Literature Review

### *Green Computing*

Every day, the world consumes a significant amount of energy to power electronic and electrical devices, particularly in the realm of information technology (IT). However, this consumption also leads to the generation of unwanted and non-functioning devices, which emit dangerous gases like CO2 and contribute to the accumulation of e-waste.

Sustainable Computing, also known as Green IT or Green Computing (GIT), encompasses the thoughtful design, utilization, disposal, and recycling of computing resources with a strong emphasis

on environmental responsibility. It involves the sustainable management of resources while recognizing the positive impacts on both the economy and the environment (Hernandez 2018). The objectives of Sustainable Computing include reducing energy consumption, minimizing the generation of electronic waste, advocating for recycling and responsible disposal of IT equipment, embracing energy-efficient technologies, optimizing operations within data centers, and promoting sustainable practices throughout the entire lifecycle of IT resources.

GIT practices encompass a wide range of strategies, such as utilizing energy-efficient devices, incorporating designs that facilitate recycling, and promoting the use of renewable energy sources. The ultimate aim of GIT is to minimize the carbon footprint and resource consumption of information and communication technology (ICT) while maximizing their societal and economic benefits. By adopting sustainable computing practices, organizations can contribute to a greener future by reducing environmental impacts and fostering more efficient and responsible use of IT resources.

The concept of GIT was developed with the aim of promoting environmental preservation. According to Ahmad (2021), GIT was established to support the implementation of a sustainable environment. Since the introduction of the Energy Star program in 1992, this concept has been utilized to provide a voluntary label for computer devices that exhibit optimal efficiency while consuming minimal energy (Mohammed et al. 2015). GIT encompasses the practices and strategies related to the use and disposal of information and communication technologies, which aim to reduce the emission of carbon and other harmful gases that negatively impact the environment (Ahmed 2018). As noted by Madkhali et al. (2023), GIT represents an eco-friendly computing approach that enables meeting the increasing demand for network computing without posing a threat to the environment. It involves policies and procedures that promote efficient utilization of computing resources, minimize energy consumption, and reduce greenhouse gas emissions (Ahmad et al. 2013). The concept of GIT has been explored by several researchers. For example, Hernandez (2020) conducted a study on GIT practices in Philippine higher education institutions. The findings revealed that various practices, including paperless and digital archiving systems, resource-efficient IT equipment, and responsible e-waste disposal, were being implemented. However, these practices were still in the early stages of adoption. Another study conducted by Mbewe (2019) examined the extent of ICT use in Higher Educational Institutions (HEIs) concerning GIT awareness and adoption. The results indicated that HEIs had a high level of ICT use, but their awareness of GIT was only moderate, and their adoption of GIT practices was low.

### *Awareness of GIT*

GIT awareness is an important factor in promoting the adoption of sustainable computing practices. It refers to an individual's understanding of the environmental impacts of information and communication technologies (ICT) and the ways in which these technologies can be used in a more environmentally responsible manner. This includes knowledge of the materials and processes used in the production and disposal of ICT products, as well as the energy consumption of different devices and the potential for energy-saving measures.

Awareness of GIT can be influenced by various factors, such as education and information campaigns, personal values and beliefs, and the availability of sustainable products and services (Ha et al. 2023). Therefore, measuring and increasing awareness of GIT is crucial for reducing the environmental impact of ICT and promoting the adoption of sustainable computing practices. This can be accomplished through efforts such as social awareness, economic sustainability, education, and outreach, as well as the development of policies and incentives to encourage the use of sustainable technologies (Adubor et al. 2022).

GIT initiatives often begin by assessing the level of awareness and adoption of GIT among students, who are the most frequent users of ICT. A study conducted by Ahmad et al. (2013) examined the knowledge of Malaysian university students regarding GIT. The results indicated that a majority of students were unfamiliar with key concepts, ideas, and issues related to GIT. Similarly, Ahmad (2021) conducted a survey on the level of awareness, acceptance, and adoption of GIT among staff and students at universities in Nigeria, which revealed a moderate level of awareness. In another research by Alamsyah et al. (2021), the role of information in customer green awareness-marketing decisions was investigated. The study found that environmental awareness is influenced by environmental knowledge

and perceived quality. Adubor et al. (2022) conducted a study exploring the relationship between green human resource management (GHRM) and corporate sustainability in manufacturing companies in Nigeria. The research findings highlighted a significant impact of GHRM factors on corporate sustainability within the manufacturing industry. Ha et al. (2023) conducted research on strategies to promote participation in a green lifestyle, starting with a survey of Korean residents. The findings revealed that while a majority of respondents acknowledged the importance of a green lifestyle, only a small portion expressed a willingness to adopt it voluntarily. Table 1 provides an overview of studies focused on GIT awareness.

**Table 1. GIT Awareness in literature**

| No | Type of Respondents | Country | Finding | References |
|---|---|---|---|---|
| 1. | students | NIGERIA | level of awareness, acceptance and practices of GIT is significantly low | (Ahmad 2021) |
| 2. | students | Malaysia | Majority of students lacked awareness of terms ideas and issues central to GIT. | (Ahmad et al. 2013) |
| 3. | faculty members, staff, and students | Ghana | Most institutions and individuals are not aware of GIT, and there are no GIT procedures in place. | (Freeman 2016) |
| 4. | students | Thailand | Green ICT products and services are still not widely used, particularly in developing countries. | (Thongmak 2016) |
| 5. | IT professionals | Malaysia | The GIT attitudes and beliefs of IT professionals are significantly influenced by leadership commitment and environmental awareness. | (Ojo and Fauzi 2020) |
| 6. | students | KSA | The awareness GIT is the most important success factor affecting the adoption of GIT | (Ahmed 2018) |
| 7. | students | United Arab Emirates | Students have a high level of awareness about GIT. Even with that level of awareness, their GIT practices are insufficient daily. | (Abugabah and Abubaker 2018) |
| 8. | supermarket customers | Indonesia | The beneficial aspects of being environmentally conscious can be changed by eco-labeling in product qualities. | (Alamsyah et al. 2021) |
| 9. | ICT centers | Nigeria | The majority of computer users are unaware of how to operate the computer system. The survey also found no statistically significant variations in GIT awareness among computer users. | (Mubarak and Augie 2020) |
| 10. | Higher Education Institutions | Zambia | GIT awareness was simply moderate, and GIT adoption was low. | (Mbewe 2019) |

| No | Type of Respondents | Country | Finding | References |
|---|---|---|---|---|
| 11. | undergraduate computing and business students | (UK) | Students are unconcerned about the sustainability of their computer practices and hardware choices, but they want policymakers to enact GIT legislation. | (Boloz 2015) |
| 12. | university librarians | Pakistan | Attitude and perceived behavioral control have a significant positive impact on the intention to adopt GIT practices. | (Soroya et al. 2022) |
| 13. | Students | Abu Dhabi, United Arab Emirates | Students have a good level of understanding of GIT, but their daily activities are insufficient. | (Abugabah and Abubaker 2018) |
| 14. | All community's | Indian | The respondents had a low level of awareness of GIT and demonstrated moderate efforts in the proper usage, disposal, and recycling of electronic gadgets. | (Bagla et al. 2022) |
| 15. | Education Sector | Philippine | In higher education institutions, the adoption of GIT practices is still in its infancy. | (Hernandez 2020) |
| 16. | Green Cloud Computing | USA | The potential of green cloud computing lies in its ability to enhance the advantages of cloud computing while simultaneously mitigating its environmental footprint. | (Sriram 2022) |
| 17. | senior managers | Philippine | Achieving sustainability requires considering significant factors such as customer satisfaction, environmental impact, and economic performance. | (Hernandez 2020) |
| 18. | employees | Nigeria | Providing employees with greening abilities and training yields numerous benefits for a company's financial performance. | (Adubor et al. 2022) |
| 19. | Inhabitants | Korea | The majority of respondents demonstrate awareness regarding the importance of embracing a green lifestyle. | (Ha et al. 2023) |
| 20. | academics and students | South Africa | GIT awareness and practices have no effect on GIT adoption. | (Obafemi et al. 2023) |

Table 1 presents a summary of various studies examining the level of GIT awareness among different groups of respondents across different countries. The studies indicate that the overall level of GIT awareness among students, faculty members, staff, and computer users is generally low to moderate, with a few exceptions (Ahmad 2021; Ahmad et al. 2013). Additionally, some studies reveal that individuals may possess a good understanding of GIT, but their daily practices related to GIT are inadequate (Freeman 2016). Furthermore, in certain institutions, the implementation of GIT procedures is lacking, and the utilization of green ICT products and services is not widespread, particularly in

developing countries (Thongmak 2016). Although awareness of GIT may be relatively high in some countries, its practical implementation remains limited (Abugabah and Abubaker 2018; Thongmak 2016). Overall, these findings underscore the importance of raising awareness and promoting the adoption of GIT practices to mitigate the environmental impact of ICT.

### *E-Waste Management*

E-waste refers to electronic products that are discarded or reach the end of their useful life, such as computers, mobile phones, televisions, and household appliances. These products often contain harmful materials, including lead, mercury, and cadmium, which can have a negative impact on the environment and human health if they are not managed properly (Awasthi et al. 2023; Madkhali et al. 2023). The amount of e-waste generated globally is increasing, with estimates indicating that over 50 million metric tons are produced each year (Statista 2023).

E-Waste Management involves the responsible handling, disposal, and recycling of electronic waste to minimize its negative environmental impact. The primary objectives of e-waste management are to promote responsible disposal practices, reduce environmental harm, and maximize resource recovery through recycling. Managing e-waste is a significant concern in the realm of GIT due to the environmental repercussions associated with the production and disposal of electronic devices. Proper e-waste management, which includes collection, recycling, and disposal, is a crucial component of GIT practices aimed at minimizing the environmental footprint of information and communication technologies (Ahmad 2021; Madkhali et al. 2023).

The study conducted by Adubor et al. (2022) highlights that offering employees training in environmentally friendly practices has a positive impact on multiple facets of a company's financial performance. These include waste reduction, material reuse, improvement of brand image, attraction and retention of environmentally conscious customers, and mitigation of adverse environmental effects. In addition to mitigating potential negative impacts of e-waste, effective e-waste management also enables the recovery of valuable materials and resources that can be utilized in the production of new products. By prioritizing proper e-waste management, organizations can contribute to a circular economy and foster sustainable practices in the IT industry.

The production of e-waste is generally higher in developed countries compared to developing nations. However, there has been a substantial surge in e-waste within developing countries, primarily driven by illegal exports and inappropriate donations of electronic equipment from developed nations (Perkins et al. 2014). This rise in e-waste poses significant challenges for developing countries, which face the dual issues of increasing e-waste generation and inadequate infrastructure for its proper collection and processing (Awasthi et al. 2023; Singh et al. 2022).

The use of sustainable materials and resource-efficient manufacturing can help to reduce the environmental impacts of e-waste (Frazzoli et al. 2022). Effective e-waste management can also minimize the risks of criminal and civil liability, operating expenses, and transportation and disposal requirements (Esikuri et al. 2019). In Nairobi County, strategic factors such as managerial capacity, institutional capacity, and resource capacity have been found to impact the successful management of e-waste (Kamau 2020). In Palestine, e-waste has become a growing issue, with 70-80% of e-waste in the country coming from illegal exports by the Israeli occupation (Esikuri et al. 2019). However, there are currently no approved methods for dealing with e-waste in Palestine and the legal framework is insufficient to address the associated risks (Al-Jabari 2014). There is also a lack of national e-waste strategies or goals and a lack of research on e-waste and GIT in Palestine. Increasing awareness of the need for GIT and the risks of e-waste is important for addressing these issues in Palestinian society. Madkhali et al. (2023) emphasize the necessity of implementing a comprehensive approach that integrates diverse management strategies to effectively address e-waste management. The study underscores the importance of enhancing public awareness concerning the appropriate handling and recycling of e-waste to achieve meaningful outcomes. According to data from the Palestinian Central Bureau of Statistics (2016), the energy, agricultural, and solid waste sectors in Palestine collectively emitted 4,645.5 million metric tons of CO2 equivalent in 2016. This constituted approximately 0.61% of the global emissions share. The energy sector accounted for 72.8% of these emissions, followed by the solid waste industry (19.2%) and agriculture (8.0%). However, Palestine lacks approved methods

for managing electronic waste, which is a growing problem. Moreover, the country's legal framework is insufficient to manage the risks associated with e-waste, as highlighted by (Al-Jabari 2014). In addition, Palestine does not have a national e-waste strategy or goals, due to factors such as inadequate funding and the illegal transfer of e-waste. Furthermore, there is a dearth of research on electronic waste and GIT in Palestine. Therefore, this study's significance lies in increasing Palestinian society's awareness of the importance of GIT and the risks of e-waste.

Within the context of these research findings, our study posits the following hypotheses.

*H1: There is a significant relationship between GIT awareness and GIT adoption.*

This study hypothesizes there is a significant correlation that exists between awareness of GIT (Green Information Technology) and the adoption of GIT practices. This hypothesis is consistent with insights from the literature, as demonstrated by Ahmed (2018) and Alamsyah et al. (2021), who emphasize that GIT practices are designed to promote sustainable computing. The effectiveness of these practices is influenced by the level of awareness individuals and organizations possess about them.

*H2: There is a significant impact of GIT awareness on GIT adoption.*

This hypothesis is grounded in established theoretical principles that highlight the crucial role of awareness as a precursor to adopting new practices. Existing literature underscores that enhancing awareness of GIT principles is a foundational step in fostering the adoption of sustainable computing practices, as indicated by Obafemi et al. (2023).

*H3: There is a statistically significant difference between gender variables on GIT awareness.*

Recognizing the importance of equitable access to GIT practices, this hypothesis aims to investigate whether gender-based disparities in GIT awareness exist. Drawing on prior research in this field, such as the work of Adubor et al. (2022).

*H4: There is a statistically significant difference between gender variables on GIT adoption.*

Gender-related differences in GIT adoption are statistically significant. Building upon insights from the literature review, which highlights the significance of inclusivity in GIT practices, this hypothesis seeks to explore whether gender plays a role in influencing the adoption of sustainable computing behaviors, this hypothesis will address research question (RQ4).

*H5: There is a statistically significant difference between students' academic levels on GIT adoption.*

this hypothesis will address research question (RQ5).

## Research Methodology

In this study, data collection was conducted through a questionnaire designed to assess students' awareness of and engagement with GIT. The construction of the questionnaire was guided by an in-depth review of the literature, as elaborated in Table 1. The survey consisted of a set of 18 questions pertaining to the GIT awareness and 14 questions focused on measuring GIT practices (refer to Appendix A and Appendix B). Participants provided responses using a five-point scale. Data analysis was performed using Microsoft Excel 2010 and SPSS 20. Several statistical techniques were employed to assess the questionnaire's reliability and validity, as well as to test the study's hypotheses. Cronbach's alpha was utilized to evaluate the questionnaire's internal consistency, thereby assuring the reliability of its measurements. In parallel, Principal Components Analysis was employed to establish the questionnaire's validity, affirming its precision in capturing the desired constructs. Descriptive analysis was utilized to determine the extent of GIT awareness and practices among the student sample. Furthermore, Pearson correlation, regression analysis, and t-tests were employed to explore the relationships between GIT awareness and adoption. Figure 1 illustrates the sequential progression of the research steps.

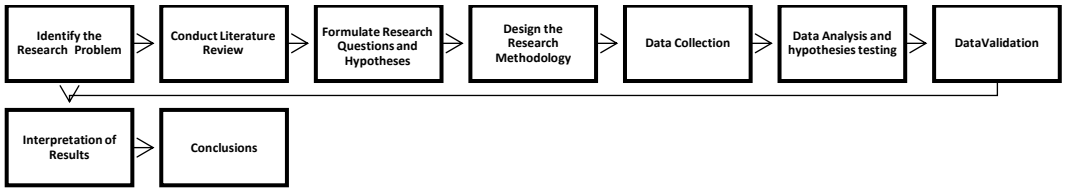


**Figure 1. Research Steps**

## *Sampling*

The study was conducted at Al-Aqsa University in Gaza, with a sample consisting of 273 undergraduate students, as shown in Table 2. Out of the total participants, 124 students (45.42%) were male, while 149 students (54.58%) were female. Regarding academic level, 47 students (17.22%) were in their second year, 84 students (30.77%) were in their third year, and the majority, 142 students (52.01%), were in their fourth year. The majority of students were pursuing a bachelor's degree, accounting for 249 students (91.21%), while 24 students (8.79%) were pursuing a diploma.

**Table 2. Demographics of the Students**

| Characteristics | | Sample Number | % |
|---|---|---|---|
| Gender | Male | 124 | 45.42 |
| | Female | 149 | 54.58 |
| Academic level | Second | 47 | 17.22 |
| | Third | 84 | 30.77 |
| | Fourth | 142 | 52.01 |
| Type of Study | Bachelor | 249 | 91.21 |
| | Diploma | 24 | 8.79 |

## *Reliability and Validity Analysis*

The reliability and validity analysis are used to examine the consistency of the questionnaires. Cronbach's alpha is a measure of internal consistency, which is a measure of how closely related the items in a questionnaire or scale are to each other. It is commonly used to assess the reliability of a questionnaire or scale. Cronbach's alpha value for the GIT Awareness and Adoption Scale was higher than 0.85, which was considered reliable for the present study.

## *Principal Components Analysis (PCA)*

In this study, Principal Component Analysis (PCA) was utilized to reduce the dimensions of students' GIT perceptions and and to validate the research instrument. The PCA method relied on Eigenvalues and cross-loading to determine the appropriate number of dimensions in the instrument. Eigenvalues played a crucial role, where components with Eigenvalues exceeding one were considered more significant, while those below one was deemed negligible. Cross-loading referred to the distribution of items across two or more dimensions. A survey was conducted involving 273 students, which underwent component analysis and varimax rotation. The findings revealed that out of the 18 items, only three dimensions exhibited Eigenvalues exceeding 1.0. As a result, six items were eliminated due to cross-loading issues. The removed items consist of Q2, Q3, Q4, Q9, Q10, and Q12 (refer to Appendix A). Consequently, the ultimate GIT awareness questionnaire consisted of 3 dimensions and 12 items, as shown in Table 3.

**Table 3. Results of Factor Analysis**

| Factors | 1 | 2 | 3 |
|---|---|---|---|
| **Factor 1: GIT Understanding** | | | |
| 1. Have an idea about green computing. | 0.614 | | |
| 2. Studying green computing in some university courses | 0.543 | | |
| 3. Using the screen saver saves power when the computer is idle. | 0.450 | | |
| 4. Green computing activities are very expensive, so the university cannot afford them. | 0.487 | | |
| 5. Many computers are produced from many hazardous materials like cadmium, mercury, and other toxic substances | 0.596 | | |
| **Factor 2: Environmental Awareness** | | | |
| 6. Green computing is very beneficial for academic institutions. | | 0.758 | |
| 7. Green computing is essential to environmental sustainability | | 0.732 | |
| 8. Laptop LCD/LED screen consumes less power than a desktop computer. | | 0.671 | |
| 9. Improper disposal of computer waste leads to the leakage of chemicals such as lead and mercury, which pollute the environment. | | 0.782 | |
| **Factor 3: E-Waste Awareness** | | | |
| 10. Recycling printer cartridges is better than refilling them. | | | 0.510 |
| 11. Recycling ICT devices is better to keep our environment clean. | | | 0.753 |
| 12. ICT equipment waste must be disposed of properly | | | 0.729 |

The factor analysis results revealed three distinct factors within the questionnaire: GIT Understanding, Environmental Awareness, and E-Waste Awareness. The GIT Understanding factor encompassed items that assessed participants' knowledge of GIT, including their understanding of GIT and awareness of the environmental impacts associated with computer production. The Environmental Awareness factor consisted of items that explored participants' recognition of the significance of GIT for environmental sustainability and their understanding of the energy-saving advantages of specific technologies. The E-Waste Awareness factor comprised items that gauged participants' understanding of the proper disposal of ICT equipment and their awareness of the environmental benefits associated with recycling. The factor loadings for each item, presented in the table above, indicated the strength of the relationship between the item and its corresponding factor, with values exceeding 0.5 indicating a robust association.

## Results and Discussion

### *The Level of Students' Awareness of GIT*

To address RQ1, this study utilized descriptive analysis to investigate the scope of students' GIT awareness. Table 4 delineates three evaluated factors within the survey: GIT understanding, environmental awareness, and e-waste awareness. The table displays the mean, standard deviation, and the percentage of respondents who agreed with each item for each factor. The items are arranged on a scale of 1 to 12, with 1 indicating the item with the highest mean and 12 representing the item with the lowest mean.

**Table 4. GIT Awareness Descriptive Statistics**

| No. | Item | Mean | % | Std. Deviation | Rank |
|---|---|---|---|---|---|
| **Factor 1: GIT Understanding** | | | | | |
| 1. | Having an idea about green computing. | 2.853 | 57.06 | 1.1807 | 11 |
| 2. | Studying green computing in some university courses | 2.137 | 42.74 | 1.3862 | 12 |
| 3. | Using the screen saver saves power when the computer is idle. | 3.696 | 73.92 | 0.8876 | 4 |
| 4. | Green computing activities are very expensive, so the university cannot afford them | 3.578 | 71.56 | 0.8377 | 7 |
| 5. | Hazardous elements including cadmium, mercury, and other poisonous compounds are used in the production of many computers. | 3.287 | 65.74 | 1.1166 | 9 |
| | | 3.11 | 62.20 | | |
| **Factor 2: Environmental Awareness** | | | | | |
| 6. | Green computing is very beneficial for academic institutions. | 3.608 | 72.16 | 0.9351 | 6 |
| 7. | Green computing is essential to environmental sustainability | 3.765 | 75.3 | 1.0453 | 3 |
| 8. | Laptop LCD/LED screen consumes less power than a desktop computer. | 3.618 | 72.36 | 0.9232 | 5 |
| 9. | Improper disposal of computer waste leads to the leakage of chemicals such as lead and mercury, which pollute the environment. | 3.882 | 77.64 | 0.9471 | 2 |
| | | 3.718 | 74.36 | | |
| **Factor 3: E-Waste Awareness** | | | | | |
| 10. | Recycling printer cartridges is better than refilling them. | 3.431 | 68.62 | 0.9175 | 8 |
| 11. | Recycling ICT devices is better to keep our environment clean. | 4.049 | 80.98 | 0.9988 | 1 |
| 12. | ICT equipment waste must be disposed of properly | 3.186 | 63.72 | 1.1918 | 10 |
| | | 3.555 | 71.1 | | |

The results in table (4) indicates that the students had a high level of awareness of GIT and its importance for environmental sustainability, with a mean of 3.718 for the environmental awareness factor and a mean of 3.555 for the e-waste awareness factor. The students had a lower level of understanding of GIT concepts and practices, with a mean of 3.11 for the GIT understanding factor. This suggests that while the students had a general awareness of the importance of GIT, they may not have had a detailed understanding of specific GIT concepts and practices. These results are consistent with a variety of studies, including those conducted by Ahmad et al. (2013) and Freeman (2016), which have emphasized the restricted comprehension of GIT among students. However, other studies have reported moderate to strong student understanding of GIT, as demonstrated by research conducted by Abugabah and Abubaker (2018) and Mbewe (2019)

### *The Level of Students' Adoption of GIT*

To address RQ1, this study utilized descriptive analysis to investigate the scope of the adoption of GIT among the students. The results in Table 5 indicated that the level of Students' adoption of GIT is generally high (72.32%). The highest levels of adoption were observed for practices such as accessing the internet and owning a computer or other ICT equipment, with 85.8% and 83.6% of students engaging in these activities, respectively. Other highly adopted practices included using the computer as necessary. and being careful to purchase e-devices that consume less energy, with 80.6% and 79.8% of students reporting these behaviors, respectively. On the other hand, some GIT practices had lower levels of adoption among the students. For example, only 48.62% of students reported using solar energy to power their computers, and 63.34% reported reading the GIT Handbook that came with their PCs. However, even for these less adopted practices, the majority of students still reported engaging in them to some degree.

**Table 5. GIT Adoption Descriptive Statistics**

| No. | Green ICT practices | Mean | % | Std. Deviation | Rank |
|---|---|---|---|---|---|
| 1. | Utilizing the internet as necessary. | 4.29 | 85.8 | 0.8395 | 1 |
| 2. | Owning a computer and other ICT equipment. | 4.18 | 83.6 | 0.9164 | 2 |
| 3. | Using the computer as necessary. | 4.03 | 80.6 | 0.9383 | 3 |
| 4. | Be careful to buy electronic devices that consume less energy. | 3.99 | 79.8 | 0.9746 | 4 |
| 5. | Using a computer for many years | 3.86 | 77.2 | 1.0812 | 5 |
| 6. | Acceptance of green computing activities. | 3.76 | 75.2 | 0.8919 | 6 |
| 7. | Switch the computer to "low power consumption" mode every time. | 3.66 | 73.2 | 1.1124 | 7 |
| 8. | Correct methods are used to dispose of unwanted computers and ICT tools. | 3.6 | 72 | 1.0075 | 8 |
| 9. | Be careful to use e-books and e-learning tools. | 3.58 | 71.6 | 1.0571 | 9 |
| 10. | Turn off the computer when not in use. | 3.554 | 71.08 | 1.2092 | 10 |
| 11. | Reducing energy consumption by powering down ICT devices. | 3.294 | 65.88 | 1.154 | 11 |
| 12. | Use of recycled paper and reduce paper consumption. | 3.23 | 64.6 | 1.3924 | 12 |
| 13. | Read the content of the Green IT Handbook that is provided with ICT equipment. | 3.167 | 63.34 | 1.2324 | 13 |
| 14. | Using solar energy to power a computer. | 2.431 | 48.62 | 1.4555 | 14 |
| Average | | 3.62 | 72.32 | | |

### *Relationship between GIT adoption and GIT Awareness*

The relationship between GIT adoption and awareness factors (GIT understanding, awareness of the environment, and awareness of e-waste) among students was investigated using the Pearson correlation coefficient, and the results are shown in Table 6.

**Table 6. The Relationship between GIT Adoption and GIT Awareness**

| Factors | Person Correlations | Sig |
|---|---|---|
| GIT understanding | 0.474** | 0.000 |
| Awareness of the environment | 0.512** | 0.000 |
| Awareness of e-waste | 0.381** | 0.000 |
| GIT awareness | 0.566** | 0.000 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | |

The strongest link between GIT awareness and GIT adoption among students (p=0.566**, Sig=0.000) is seen in table 6. This indicates that there is a positive relationship between GIT awareness and GIT adoption among students. Hence, the first hypothesis (H1) is accepted.

### *The Effect of GIT Awareness on GIT Adoption*

In this study, the impact of GIT awareness on GIT adoption among students at al-Aqsa University in the Gaza strip was analyzed by stepwise multiple regression. The results of the regression analysis were revealed as presented in Table 7. The value of R is 0.576, and the p-value is 0.000, indicating that GIT awareness and adoption are positively associated, according to the regression analysis. GIT awareness accounts for 32.5% of the total variance in the dependent variable (GIT adoption).

**Table 7. Regression Models (GIT Awareness: GIT Adoption)**

| Model | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| (Constant) | 1.583 | 0.164 | | 9.658 | 0.000 |
| Environmental Awareness | 0.242 | 0.043 | 0.332 | 5.575 | 0.000 |
| GIT Understanding | 0.226 | 0.061 | 0.230 | 3.726 | 0.000 |
| Awareness of e-Waste | 0.105 | 0.043 | 0.138 | 2.425 | 0.016 |
| **Where, R**=.576**, $R^2$**=.332**, Adjusted $R^2$**=0.325**, F value**=45.99**, Sig. =0.000** | | | | | |

The regression equation (Equation 1) predicted the following based on these findings:

$$\text{GIT Adoption} = 1.583 + .242\ \text{GIT Environmental Awareness} + 0.226\ \text{GIT Understanding} + 0.105\ \text{Awareness of e} - \text{Waste} + e$$

Equation (1)

The previous equation has indicated that an increase in GIT awareness factors (GIT Environmental Awareness, GIT Understanding, and Awareness of e-Waste) will have a positive impact on GIT Adoption. Therefore, the second hypothesis (H2) is accepted. This outcome aligns with the findings from the study by Ahmed (2018), underscoring the significance of GIT awareness in GIT adoption. However, it contrasts with the outcomes of the research conducted by Obafemi et al. (2023), which concluded that GIT awareness and practices hold no influence over GIT adoption.

### *Gender Differences in GIT Awareness and Adoption*

The analysis of GIT awareness and adoption by gender aims to determine if there are any gender-based differences in how IT students at Al-Aqsa University in Gaza perceive and adopt GIT practices. statistically significant impact on GIT awareness. Similarly, there is no significant difference between GIT adoption and gender [t = 0.070, p = 0.994 > 0.05], implying that there is no relationship between

gender and GIT adoption. Based on these the results of this analysis can help identify any potential areas where targeted interventions may be necessary to improve GIT awareness and adoption among male and female students. Table 8 shows the results of an independent t-test done on two independent groups to investigate gender differences in GIT awareness and adoption. Table 8 indicates that there is no significant difference between gender and GIT awareness [t = 0.043, p = 0.966 > 0.05]. The analysis indicates that gender does not have an impact on GIT awareness and adoption. As a result, the third hypothesis (H3) and fourth hypothesis (H4) are both rejected.

**Table 8. The differences of gender in GIT awareness and Adoption**

| Factor | Sig. (2-tailed) | t | Mean | | Std. Deviation | |
|---|---|---|---|---|---|---|
| | | | Female | Male | Female | Male |
| GIT awareness | 0.966 | 0.043 | 3.4435 | 3.446 | 0.50448 | 0.5685 |
| Adoption GIT | 0.994 | 0.070 | 3.4530 | 3.4575 | 0.50116 | 0.04105 |

### *Academic level Differences in GIT Awareness*

A one-way analysis of variance (ANOVA) was conducted to determine whether there is a significant difference in the mean of GIT awareness among students at different academic levels. Table 9 shows that there was no statistically significant difference in mean scores for GIT awareness between student academic levels [F = 0.973, p = 0.522 > 0.05]. This suggests that academic level does not have a significant impact on GIT awareness. As a result, the fifth hypothesis (H5) is rejected.

**Table 9. One-way ANOVA for Academic Level and GIT**

| Source of Variation | SS | Df | MS | F | P-Value |
|---|---|---|---|---|---|
| Between Groups | 22.532 | 40 | 0.563 | 0.973 | 0.522 |
| Within Groups | 127.911 | 221 | 0.579 | | |
| Total | 150.443 | 261 | | | |

The outcomes of hypothesis testing indicate a notable influence of the independent variable (GIT awareness) on the dependent variable (GIT adoption). These findings are visually presented in Figure 2.

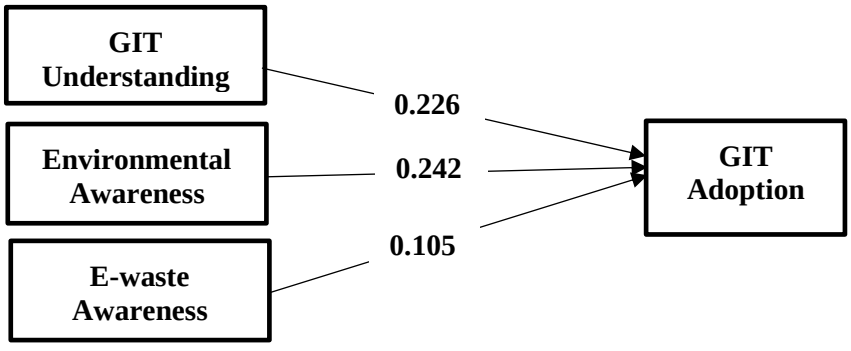


**Figure 2. GIT Adoption Barriers Model**

# Implications

## *Theoretical Implications*

This study contributes significantly to the theoretical understanding of the relationship between GIT awareness and adoption. It solidifies the existence of a positive correlation between awareness and adoption, offering valuable insights that can enhance existing theories related to technology adoption and environmental behavior. Furthermore, the identification of a substantial awareness-action gap, where awareness doesn't always translate into action, aligns with established theories in psychology and behavioral economics. This stresses the critical need to address barriers that impede behavioral change, even when individuals are aware of the benefits associated with the sustainable practices. Additionally, this research challenges conventional assumptions about gender disparities in technology-related behaviors by demonstrating that there are no significant gender differences in GIT adoption. These findings contribute to the development of theories regarding gender and technology adoption. Lastly, the observation that academic level has minimal influence on GIT awareness suggests the consistent integration of GIT concepts throughout the academic journey, enriching our theoretical understanding of how technology and sustainability education are interwoven into IT programs.

## *Practical Implications*

In terms of practical implications, the outcomes of this study hold promise for policy development and guidelines concerning GIT adoption. Educational institutions can leverage these findings to bolster GIT awareness among IT students. This includes the integration of GIT principles, e-waste management topics into the curriculum, as well as organizing awareness campaigns and workshops. While academic level does not significantly affect GIT awareness, institutions should persist in their efforts to maintain and enhance GIT awareness among students at all academic levels, emphasizing the importance of continuous education and awareness campaigns to ensure long-term GIT adoption. The study underscores the necessity for behavioral interventions that bridge the awareness-action gap, offering practitioners the opportunity to design targeted interventions addressing specific barriers preventing individuals from translating their GIT awareness into action. Moreover, businesses and organizations can utilize these findings to inform their sustainability initiatives, potentially involving the adoption of energy-efficient technologies and responsible e-waste management practices. Finally, this study highlights areas where additional research is warranted, particularly in exploring the factors influencing GIT adoption, thereby guiding future research endeavors within the realm of GIT and sustainability.

# Conclusion

This research aimed to examine the level of GIT awareness and adoption, as well as the relationship between GIT awareness and GIT adoption, among IT students at Al-Aqsa University in Gaza. The findings revealed a moderate level of GIT awareness and a high level of GIT adoption among the students. While a significant number of students recognized the importance of recycling ICT devices, proper e-waste disposal, and practicing GIT, there was a gap between awareness and actual implementation. Although a majority of students acknowledged the significance of computer waste disposal and GIT practices, a smaller percentage actively engaged in using solar energy to power computers or using recycled paper. These results indicate that while the students possessed a general understanding of GIT principles, there is room for improvement in integrating these practices into their daily lives. Furthermore, the study demonstrated a positive association between GIT awareness and adoption, suggesting that increased awareness leads to higher levels of adoption. However, no significant gender differences were observed in terms of GIT awareness and adoption among the students. This study underscores the significance of formulating a well-defined strategy for the implementation of GIT and ensuring the appropriate disposal of e-waste, especially considering the unique context of Palestine, which is impacted by the recycling practices of neighboring countries. The findings highlight the need for Palestinian authorities to prioritize the establishment of effective mechanisms for GIT adoption and proper e-waste management. Given the increasing global concern over e-waste and its environmental implications, it is essential for Palestine to develop robust strategies and policies that address the challenges associated with e-waste recycling. This includes initiatives

aimed at raising awareness among individuals, organizations, and institutions about the importance of responsible e-waste disposal practices and the adoption of GIT principles. By implementing comprehensive measures and regulations, Palestine can mitigate the negative environmental impact of e-waste and create a more sustainable computing ecosystem. Collaborative efforts between government agencies, educational institutions, and relevant stakeholders are crucial in achieving effective GIT adoption and ensuring proper e-waste management. Furthermore, international cooperation and knowledge sharing can play a vital role in supporting Palestine's efforts to establish a sustainable GIT framework and develop local capacity in e-waste management. By addressing these challenges and embracing GIT practices, Palestine can contribute to a more environmentally conscious and technologically sustainable future. This study is subject to several limitations. Firstly, the study's sample was limited to IT students from a single university located in a specific geographical area. Moreover, while the study extensively investigated various aspects of GIT awareness, it might not have taken into account all the variables that could influence adoption behaviors. In the future, it is recommended that research delve more extensively into these variables to establish a comprehensive understanding of the factors that contribute to the adoption of GIT.

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## Appendix A

GIT Awareness Measurement Questionnaire

Please use the checkmark (√) to indicate your level of approval on the following axes:

| GIT Awareness | | Strongly agree | Agree | Moderate | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| Q1 | I have an idea on GIT. | | | | | |
| Q2 | GIT focuses on using computers and related technology in a way that uses the least amount of energy possible. | | | | | |
| Q3 | Hazardous chemicals are used in the manufacture of computers | | | | | |
| Q4 | I've read a number of articles and academic papers on GIT. | | | | | |
| Q5 | The media has informed me about GIT. | | | | | |
| Q6 | I have taken various university courses on GIT. | | | | | |
| Q7 | Green computing is very beneficial for academic institutions. | | | | | |
| Q8 | GIT is essential to environmental sustainability | | | | | |
| Q9 | Laptop LCD/LED screen consumes less power than a desktop computer. | | | | | |
| Q10 | Computer use is growing, which contributes to global warming. | | | | | |
| Q11 | When the computer isn't in use, the screen saver helps conserve power. | | | | | |
| Q12 | Your computer will use more energy if you turn it off and on again frequently than if you leave it on. | | | | | |
| Q13 | Because they are so expensive, green computing initiatives are not something the institution can afford. | | | | | |
| Q14 | Instead than replenishing printer cartridges, recycle them. | | | | | |
| Q15 | Chemicals such as lead and mercury seep from improper computer trash disposal, harming the environment. | | | | | |
| Q16 | ICT device recycling is preferable for maintaining a clean environment. | | | | | |
| Q17 | Hazardous elements including cadmium, mercury, and other poisonous compounds are used in the production of many computers. | | | | | |
| Q18 | Waste from ICT equipment must be appropriately disposed of. | | | | | |

# Appendix B

GIT Adoption Measurement Questionnaire

Please use the checkmark (√) to indicate your level of approval on the following axes:

| GIT Adoption | | Strongly agree | Agree | Moderate | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| Q1 | I recycle my old PCs and ICT equipment properly. | | | | | |
| Q2 | I make sure to get electrical equipment that consumes little energy. | | | | | |
| Q3 | I make use of electronic books, libraries, and learning materials. | | | | | |
| Q4 | I'm open to participating in green computing activities. | | | | | |
| Q5 | I've been using a computer for a long time. | | | | | |
| Q6 | I typically spend hours each day on the computer. | | | | | |
| Q7 | I essentially spend a few hours each day online. | | | | | |
| Q8 | I have access to computers and other ICT tools. | | | | | |
| Q9 | I use a laser printer to print documents, memoranda, chores, notes, etc. | | | | | |
| Q10 | Every time, I set the computer in "low power consumption" mode or leave it there all the time. | | | | | |
| Q11 | I power my computer with solar energy. | | | | | |
| Q12 | Instead of putting my computer to sleep, I shut it down. | | | | | |
| Q13 | The use of GIT can lower university facility costs and preserve a sustainable environment. | | | | | |
| Q14 | I regularly read the material in the GIT guide that comes with my computers. | | | | | |

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