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# Investigate the Bi2Se3 Crystal, which is a Three-Dimensional Topological Insulator

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**Abstract**
Topological insulators are materials that in bulk mode have band gap such as an ordinary insulator but can protect the conduction mode at the edge or surface, i.e. apart from a simple and insulated metal. These materials are insulator in their bulk modes but are metal at the surface. Topological insulators are developed in two and three dimensions. Recently, compounds of the $Bi_2Se_3$ have attracted a huge attention because of existence of a Dirac cone in their surface state, having a suitable bandgap (0.3 eV), and easy santhesis. In this research, we investigate the properties of this material using density functional theory. The main focus is on bulk calculations and surface properties. The band structure of this material is studied in bulk mode without any consideration of spin - orbit interaction. Then a surface of this material is considered and its band structure and density of states are studied. The results show that the surface of this material has a Dirac cone.

**Keywords:** Insulator, Density Function Theory, Bi2Se3, Topological Insulator, Band Structure, Dirac Cone

## 1. Introduction

Until the discovery of the quantum Hall effect in 1980 by Professor von Klitsenick (Moore, 2010), Different materials were classified based on symmetry failure. But with the discovery of the quantum Hall effect, it was seen that this new matter could not be classified on the basis of symmetry failure, because there are no more local order parameters here. A topological invariant is needed to describe the new phase.

Topological phases do not show any kind of failure of general symmetries and common local order parameters. These phases usually introduce insulation as a material that does not conduct electricity. In most insulators, the absence of electric current is described by the strip theory of solids. In recent years, a new type of insulation with a different topological strip structure with conventional insulation has been theoretically predicted. Accordingly, the new phase state is called topological insulation.

Topological insulations are theoretically predicted and experimentally observed in various systems including quantum wells (Bernevig, Hughes, & Zhang, 2006; König et al., 2008) HgTe, alloys such as Bi2Sb3 (Gehring et al., 2013; M. Zahid Hasan & Charles L. Kane, 2010) and Bi2Te3 (M. Z. Hasan & C. L. Kane, 2010) and crystals of Bi2Se3 (Gehring et al., 2013; M. Z. Hasan & C. L. Kane, 2010) Is. In topological insulations, if a perpendicular exchange field enters its surface, it can eliminate surface states and the conductive surface of the topological insulator behaves like an insulator. If the exchange magnetic field enters in the direction of the plate, it has no effect on the surface states. Topological insulations are divided into two parts: two-dimensional insulations and three-dimensional insulations and have been studied.

The most basic state of a material is the state of insulation, and insulation is a material that has an energy gap that separates full and empty strips. The simplest insulator is an atomic insulator, in which electrons are attached to atoms in closed shells.

Due to the quantum hall, a strong magnetic field is applied to the two-dimensional electron gas system at very low temperatures. Under the conditions, it is observed that there is current inside the surface of the insulation system and only at the edges, and the changes in the resistance of the hall in terms of field are no longer linear, but change stepwise(M. Z. Hasan & C. L. Kane, 2010).

$$\sigma_{xy} = \frac{Ne^2}{h} \qquad (1)$$

In this interface N is an integer (N = 1,2,3…). In quantum effects, the inverse symmetry of time is broken due to the presence of an external magnetic field.

Due to quantum spin, the direction of motion of electrons depends on its spin direction, and electrons with different spins move in two opposite directions. Having the inverse symmetry of time prevents these edge currents from scattering in the presence of impurities (non-magnetic). The presence of such spin currents without scattering and in the absence of an external magnetic field is useful for use in Tronic Spins. The effect of quantum hall spin was theoretically predicted in 2006 by Bernevig , Hughes, and Zheng in the mercury telluride quantum well (M. Z. Hasan & C. L. Kane, 2010) and was experimentally observed in 2007 by Koenig et al. (M. Z. Hasan & C. L. Kane, 2010).

Topology is actually a mathematical concept used in mathematics for general classification of shapes. In fact, shapes can be transformed by dragging and turning into another shape. Of course, without tearing, these shapes are topologically equivalent, but may be different in appearance. It must be borne in mind that the mathematical concept of the Gauss-Bonne theorema more, if we take the integral from the curvature of Barry in the Brillouin region, the results will always be discrete values, which are called Chern number (Kane, 2008; Liu et al., 2011). The topological classification in terms of the Chern number, also called the TKNN invalid in physics, is for insulators in which the symmetry of time reversal is broken. In insulations in which the inverse symmetry of time is maintained (insulations are two-dimensional or the same effect of quantum hall spin), the Chern number is zero (M. Zahid Hasan & Charles L. Kane, 2010). Therefore, to classify them, another topological invalid is needed, which is called Z2 invalid (M. Zahid Hasan & Charles L. Kane, 2010). Invalidity of Z2 takes two values of zero and one. For example, it becomes zero for a vacuum and equal to one for the quantum Hall effect. Only one Z2 invariant is required to classify two-dimensional topological insulation, and four Z2 invariant is required to classify three-dimensional topological insulation (Fu, Kane, & Mele, 2007).

Three-dimensional topological insulation (which is insulated in volume but has conductive surfaces) was also theoretically predicted in 2007 by Liang Fu and Qin (M. Z. Hasan & C. L. Kane, 2010) and was observed experimentally in 2008 by Hsieh et al (M. Z. Hasan & C. L. Kane, 2010; Lin et al., 2010). In 2009, Hsieh et al. Experimentally observed a three-dimensional sample of topological insulation (Bi2Se3), which has two special advantages over previous samples (M. Zahid Hasan & Charles L. Kane, 2010; Maciejko et al., 2009). First, it has a larger energy gap (about 0.3ev) than previous models such as the Bi2Sb3, which gives it a topological insulation at room temperature. Second, its surface states have only one Dirac point in the gap, which is the simplest possible situation. Topological insulators have special properties that can be useful for applications from spintronics to quantum computing.

## 2. Brief introduction of topological insulators

As mentioned earlier, topological insulators are materials that are insulating in volume but have conductive properties along their boundaries. In fact, along the mazes, there are edge states that are without gaps, these metal edge alignments are formed by the specific topology of these materials.

Topology is essentially a branch of mathematics in which mathematicians divide geometric objects into different topological categories (Figure1). The topological branches of each geometric shape assign a topological number (constant) called the topological constant. In fact, the difference between topological insulation and conventional insulation is in their topological constant. Heavy elements as well as semiconductors with small energy gaps are better candidates for making topological insulations. Theoretical and experimental predictions of topological states in two and three dimensions, has made one of the most important and growing topics in the physics of dense matter today. Apart from being an important tool for basic concepts, topological insulators are also used in chemicals, and they also provide new ways to build and produce new devices, which are widely used in the spintronics industry and quantum computing.

In addition to experimental advances, there is a need for atomic modeling of these materials, which allows for quantitative predictions and comparisons with experiments. Significant advances have been made in the initial methods for calculating the electrical and magnetic properties of TI (Pertsova & Canali, 2014).


Figure 1: Example of two objects that are topologically different.

## 3. A review of the crystal composition of Bi2Se3

Because the research element of this dissertation is the composition of $Bi_2Se_3$ crystal, first, the Bise crystal is briefly introduced. The $Bi_2Se_3$ family of compounds a rhombohedral crystal structure with space group $D_{3d}^5$ $R\bar{3}m$, we take $Bi_2Se_3$ as an example in the following. As shown in figure 2(a), the system has a layered structure with five atomic layers as a basic unit (cell), named a quintuple layer (QL). The inter-layer bonding within the QLs is strong because of the dominant covalent character, but the bonding between the QLs is much weaker due to the van der Walls-type interaction. The binary (with twofold rotation symmetry), bisectrix (appearing in the reflection plane) and trigonal (with threefold rotation symmetry) axes are taken as the x, y and z axes, respectively, and the primitive translation vectors $t_{1,2,3}$ shown in figure 2 are

$$t_1 = \left(-\frac{a}{2}.-\frac{\sqrt{3}a}{6}.\frac{c}{3}\right).t_2 = \left(\frac{a}{2}.-\frac{\sqrt{3}a}{6}.\frac{c}{3}\right)\text{، }t_3 = \left(0.\frac{\sqrt{3}a}{3}.\frac{c}{3}\right) \qquad (2)$$

Here, a and c are lattice constants in the hexagonal cell. The corresponding reciprocal vectors $s_{1,2,3}$ defined by $S_i.t_j = 2\pi\delta_{ij}$ are given as(Zhang, Yu, Zhang, Dai, & Fang, 2010)

$$s_1 = \left(-1\text{،}-\frac{\sqrt{3}}{3}\text{،}b\right)h\text{،}\ s_2 = \left(1\text{،}-\frac{\sqrt{3}}{3}\text{،}b\right)h\text{،}\ s_3 = \left(\frac{0.2\sqrt{3}}{3}.b\right)h \qquad (3)$$

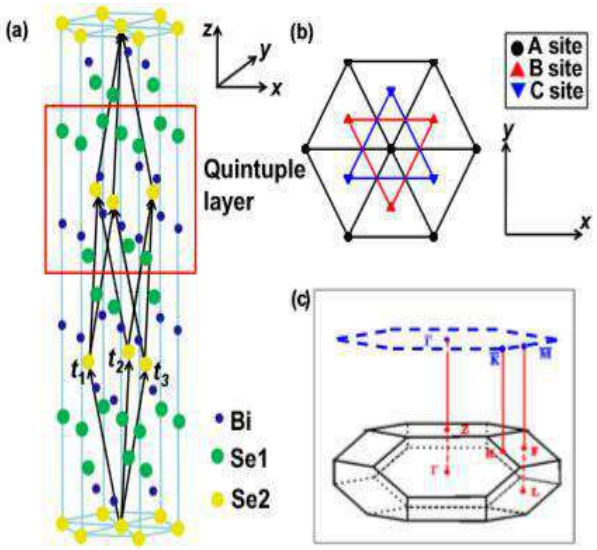


Figure 2. Crystal structure of the $Bi_2Se_3$ family of compounds. (a) The hexagonal supercell containing 15 atomic layers and primitive translation vectors $\mathbf{t}_{1,2,3}$. (b) The top view of a QL in the triangle lattice. Three sets of different sites, labeled as A, B and C sub lattices, respectively, are presented. Owing to the $D_{3d}^5$ symmetry, the stacking of atomic layers along the z-direction is the order of …-C(se1)-A(se1)-B(Bi)-C(se2)-A(Bi)-B(Se1)-C(se1)…(c) The first BZ. Four nonequivalent TRIM points $\Gamma(0,0,0)$, $L(\pi,0,0)$, $F(\pi,\pi,0)$, and $Z(\pi,\pi,\pi)$ are denoted in the 3D BZ. The corresponding surface 2D BZ is represented by the dashed blue hexagon, and $\bar{\Gamma}$, $\bar{M}$ and $\bar{K}$ are the corresponding TRIM special K points in the surface BZ(Zhang et al., 2010).

With

$$b = \frac{a}{c} \quad , \quad h = \frac{2\pi}{a} \tag{4}$$

As shown in figure 2(a), we take Se2 to be at the origin (0,0,0), then two Bi sites are at $(\pm\mu \pm \mu \pm \mu)$, and two Se1 are at $(\pm v \pm v \pm v)$, defined in the unit of primitive translation vectors. All the experimental lattice parameters and internal parameters $\mu$ and $v$ are listed in table 1. Figure 2(c) shows the 3D first Brillouin zome (BZ) and the 2D surface BZ of $Bi_2Se_3$. $\Gamma(0,0,0)$, $L(\pi,0,0)$, $F(\pi,\pi,0)$, and $Z(\pi,\pi,\pi)$ are four time-reversal invariant momentum (TRIM) points in 3D BZ. $\Gamma(0,0,0)$ and $Z(\pi,\pi,\pi)$ are projected as $\bar{\Gamma}$, and $L(\pi,0,0)$ and $F(\pi,\pi,0)$, are projected as $\bar{M}$ in the surface BZ. For the choice of our cell, $Bi_2Se_3$ has the inversion symmetry with inversion center at $Se_2$. The space group $R\bar{3}m$ can be constructed from three symmetry generators: I (inversion), $C_{3Z}$ (threefold rotation around z) and $\sigma_x$ (mirror plane with its normal along x)(Hixson & Fritz, 1992; Zhang et al., 2010).

**4. Calculation of the band structure of Bi2Se3 crystal compound**

$Bi_2Se_3$ crystal is a strong three-dimensional topological insulator. We want to calculate its band structure. In calculating the strip structure, a five-layer crystal is used, each layer containing three atoms, which is a total of 15 atoms. It should be noted, however, that the $Bi_2Se_3$ crystal in this calculation contains five atoms in a single cell (of which 2 atoms belong to bismuth and 3 atoms to selenium). The crystal structure of $Bi_2Se_3$ was fabricated using ATK software. The strip structure of $Bi_2Se_3$ with and without spin-circuit interaction (SOC) was also calculated. In the calculation by approximation, the generalized slope gradient or gga (taking into account the spin-orbit) shown by Figure (3) forms a direct gap of 0.1255 eV at the gamma point. spin-orbit pairing in sogga calculations has a significant effect on the band structure, which expands the direct band gap at the gamma point and forms an indirect gap such that a band gap in the sogga calculation (excluding spin-orbit) It is 0.3202 eV, as shown in Figure (4). $Bi_2Se_3$ crystal is still semiconductor.

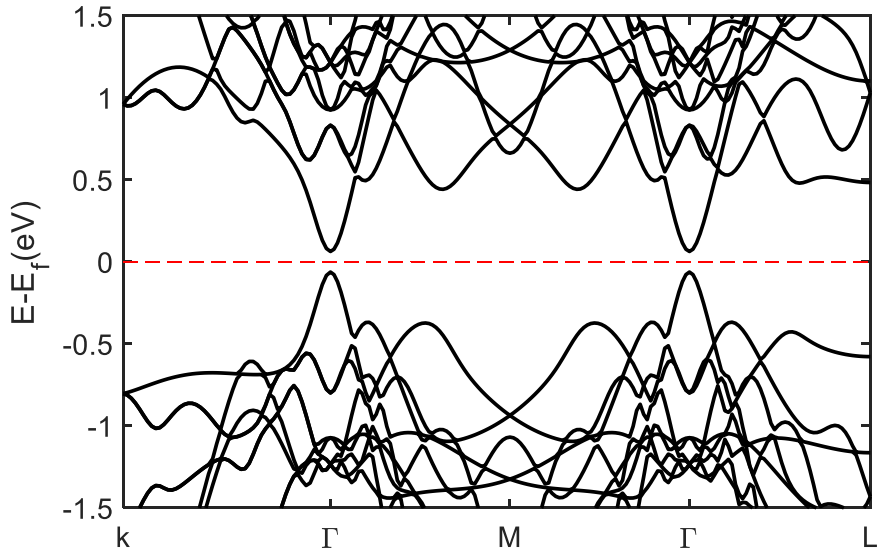


Figure 3: Shows the bulk band structure of Bi2Se3 crystal with gga calculation.

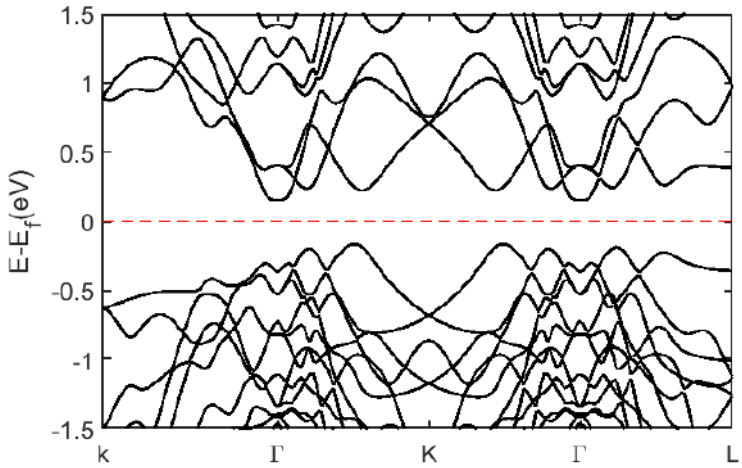


Figure 4: Shows the bulk band structure of Bi2Se3 calculated by sogga.

**5. Calculation of the band structure of the two-dimensional cut sheet (slab) of the Bi2Se3 crystal**

The calculation of the shear bond structure of the $Bi_2Se_3$ crystal is shown in Figure (5). In this case, only the calculation is done with sogga, which shows significant changes in the crystal structure. A small, direct gap (0.0077 eV) is formed at the gamma point, and the Dirac cone is still clearly visible inside the band gap. In fact, we are witnessing a topological behavior. The transition from the bulk to a cut sheet has led to the appearance of the Dirac cone and the closure of the gap.

It is further noted that the electronic structure of the surface states close to the Fermi surface resembles a Dirac cone, where the electron momentum depends linearly on the energy. Since surface states are the only states present within the bulk energy gap, we should expect the electron density of states close to Fermi energy ($E_f$) to be linear. Here we calculate the electron density, in the calculated diagram of the electron density of the Dirac cone above the Fermi energy level. The electron densities of bismuth and selenium were calculated separately, the result showing that the p orbital has the highest share in both elements and the s orbital has the lowest share in both elements. As can be seen in the Bi2Se3 crystal, the share of selenium is higher than that of bismuth, which is shown by Figures (6, 7 and 8).

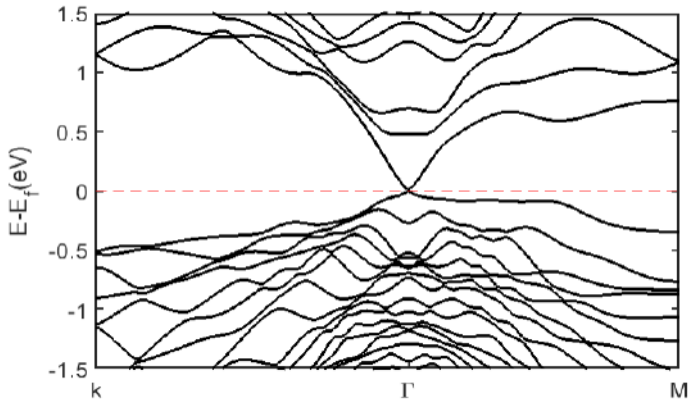


Figure 5: Shows the band structure of Bi2Se3 cut sheet by sogga calculation.

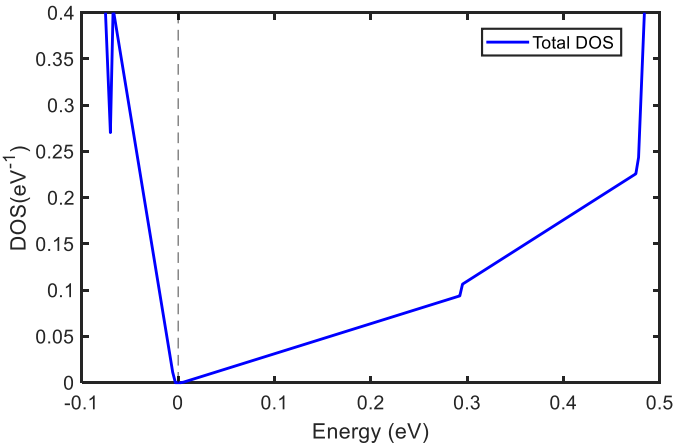


Figure 6: Shows the electron density diagram of the cut sheet of Bi2Se3.

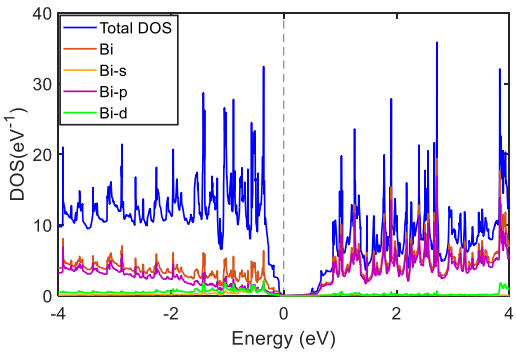


Figure 7: Shows the comparison of the total electron density with the electron density of bismuth crystal Bi2Se3.

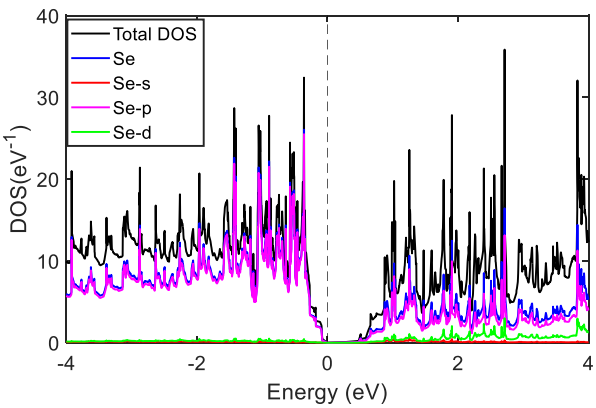


Figure 8: Shows the comparison of the total electron density with the electron density of Bi2Se3 crystal selenium.

### 6. Apply strain to $Bi_2Se_3$ crystal

$Bi_2Se_3$ crystal is chemically stable, showing a strong topological phase for easy synthesis. Theoretical and experimental studies that have been done on it, introduce it as a prototype of topological insulation and is a natural choice for initial research. There is also interest in the effect of mechanical strain on topological effects. There is also interest in the effect of mechanical strain on topological effects. Therefore, for the $Bi_2Se_3$ block mode, the effect of arbitrary pressures of 2% and - 2% on the gap at the gamma point and with the bond structure with spin-orbit interaction has been calculated. It was observed that the application of 2% strain (tensile strain) reduces the energy gap and reaches 0.0095 eV and is straight. From the obtained electron density of the mentioned structure, it can be seen that the Dirac cone is below the Fermi energy level, indicating the metallization of the $Bi_2Se_3$ crystal.

By applying a 2% strain, the band gap is reduced to about (0.0083 eV) and is straight. It has a Dirac cone structure, in which the gap and the Dirac cone both form above the Fermi energy level at the gamma point, thus increasing the semiconductor properties of the $Bi_2Se_3$ crystal. Also, the electron density of the relevant structure has been calculated, which indicates the Dirac cone on the Fermi energy surface and indicates that the $Bi_2Se_3$ crystal is semiconductor. All results are shown by Figures (11, 12, 13 and 14) below.

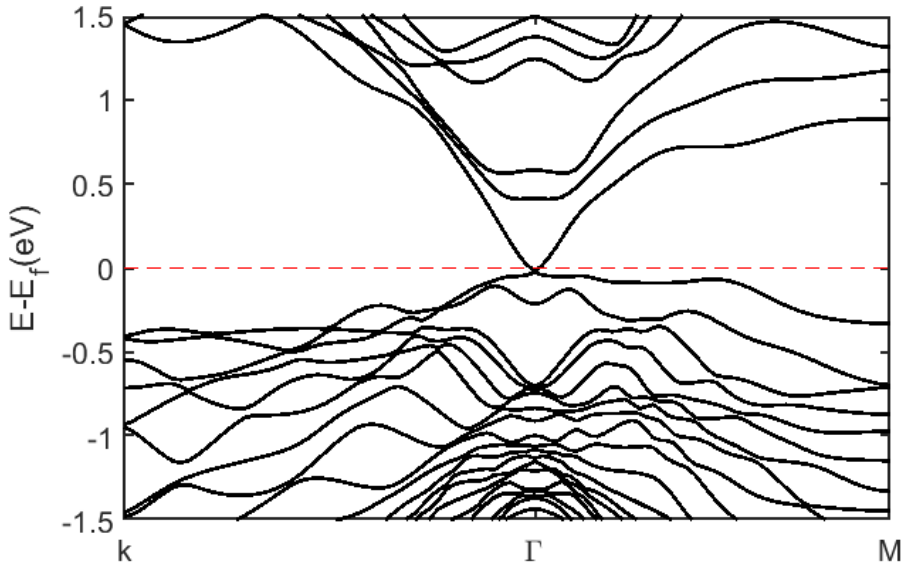


Figure 9: Shows the energy band structure diagram of applied 2% Bi2Se3 strain.

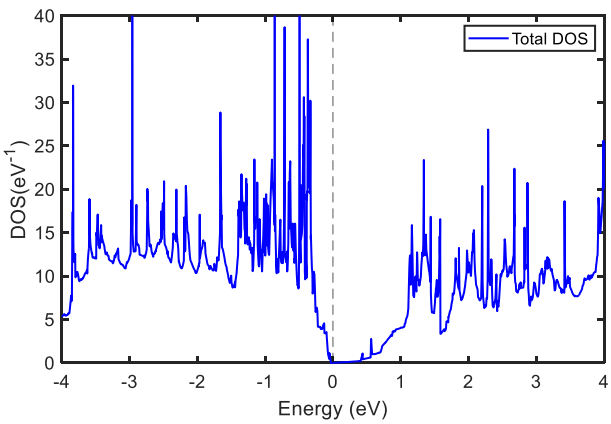


Figure 10: Shows the electron density diagram of 2% strain applied to the Bi2Se3 crystal

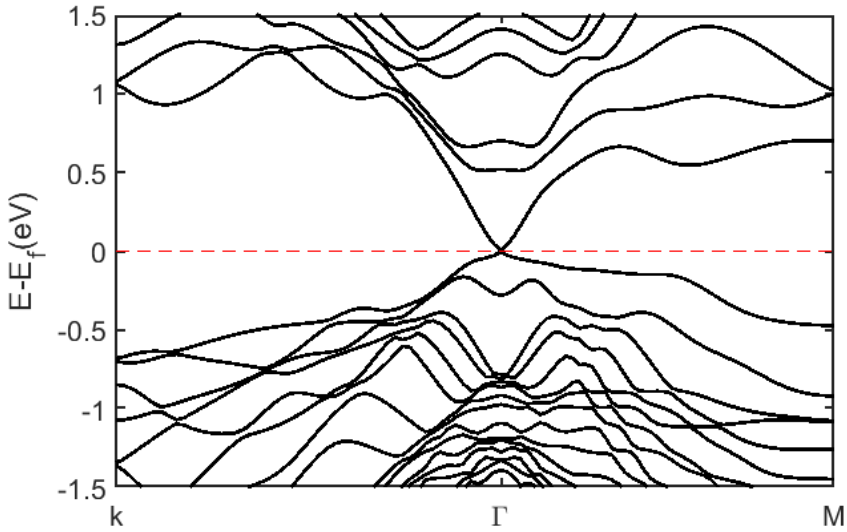


Figure 11: Shows the energy band structure diagram of -2% applied strain on the Bi2Se3 crystal.

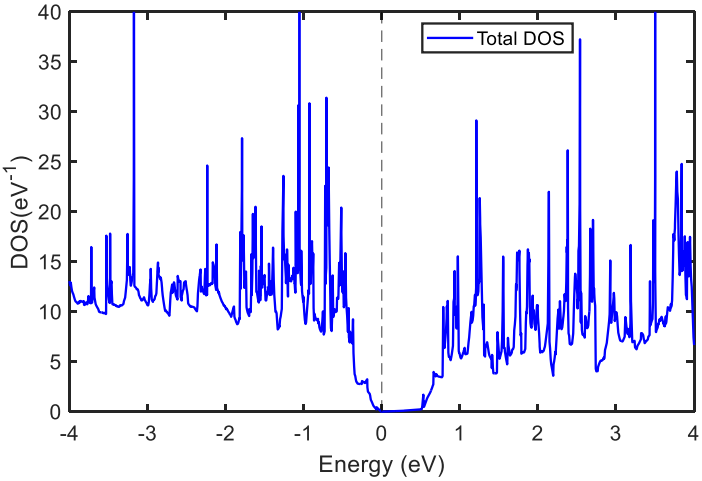


Figure 12: Shows the electron density diagram of -2% strain applied to the Bi2Se3 crystal.

## 7. Conclusion

In this research, first an attempt was made to form the crystal structure of Bi2Se3, and the band structure, total electron density, electron density of each element of bismuth and selenium were calculated separately and compared. In calculating the band structure before cutting, a bigger gap was obtained.

After cutting the gap, the energy of the Bi2Se3 bond structure decreased and its semiconductor properties increased. For larger gap cuts, the energy will decrease more and the crystal will become semi-conducting. In addition, 2% and -2% strain were also applied to the Bi2Se3 crystal. After calculating its band structure and electron density, it was observed that tensile strain cause a further reduction of the energy gap. From the observations of the obtained results, it can be said that the metallic properties of the Bi2Se3 crystal have increased and can go towards metallization.

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# Implementation of the Rapid Application Method Development (RAD) in Clothes Sale Website Design

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**Abstract**
Rapid Application Development (RAD) is a software development method that speeds up software production by reducing complex and time-consuming processes. RAD can be used as a reference for developing superior information systems in speed, accuracy and lower cost. In this study, the application of the RAD method will be carried out to design a business website selling Mamigaya breastfeeding clothes by testing using EUCS and blackbox testing. The first phase of RAD is understanding fast design system analysis & requirements. Requires a high level or knowledgeable end user to define what the system function should be. The second stage is a repetition of the prototype cycles development stage, namely development, demonstration, refine. This includes creating physical designs for databases and mainly focuses on translating designs into programming code. Based on the results obtained from a survey using EUCS, the satisfaction level of respondents reached 88.58% and the results of blackbox testing showed that the features on the website could function. Thus, it can be concluded that the application of RAD can produce a good website.

**Keywords:** Web Design, RAD, Mamigaya, EUCS

## 1. Introduction

RAD is a software development method that speeds up software production by reducing thecomplicated and time-consuming planning process.RAD can be used as a reference for developing an information system that is superior in terms of speed, accuracy and lower cost (Flora, 2018). The RAD model is an adaptation of the waterfall model, where rapid development is achieved using a component-based construction approach (Subhiyakto & Astuti, 2019). The RAD method works bymeans of an iterative and incremental approach, whichmeans that all application projects are developed in stages through repeated iterations. This iterationallows app developers to create, review, and modify apps based on feedback. The RAD method has a technical flow in speeding up the

website development process, such as Prototyping, Rapid Modeling, Timeboxing, and Reuse Components (Beynon-Davies et al., 1999). This methodis widely used in website design and runs with a good success rate.

In this study, the application of the RAD method will be carried out to design a website for the Mamigaya breastfeeding clothing sales business. Mamigaya is a brand from a shop that sells various models of nursing clothes that are produced at a convection in the Bandung area, West Java. Mamigayahas been initiated since 2012. This business is run by Faridah Alawiyah as the owner of Mamigaya, sales aremade online through various marketplace applicationssuch as Shopee, Tokopedia, Lazada, Facebook, and also market it offline operating at home.

However, when using the marketplace, you will always get a sales discount from the application everytime you make a transaction. The commission percentage that is commonly charged by some marketplaces varies from 1% to 20%. So this makes Mamigaya need to provide a sizable commission to the application if Mamigaya makes a lot of transactions on the marketplace. In using applications from third parties such as marketplaces also have greater competition compared to e-commerce. So based on the results of interviews with Mamigaya, Mamigaya needs a sales application website that can also provide educational information about breastfeeding clothing products.

## 2. Related Theory

### *2.1 Profile Mamigaya*

Mamigaya is a brand from a shop that sells variousmodels of nursing clothes that are produced at a convection in the Bandung area, West Java. Mamigayahas been initiated since 2012. This nursing clothes business is run online through various marketplace applications such as Shopee, Tokopedia, Lazada, Facebook, and also markets it offline operating athome. Mamigaya specifically sells clothes for breastfeeding mothers.

The nursing clothes sold by Mamigaya have various models and categories, starting from the basicssuch as Elsha, Pappi, Sofie. Then there are maxi dresses such as the Izza Maxi Series, Abaya Series, Aulia Maxi Series, Aisyah Gradasi Merah, Reina Denim Square, Midi Kania, and many more.Based on the results of the interviews conducted with Mamigaya, the various models of nursing clothes that are sold by Mamigaya are made with comfortable materials and follow the style of young mothers so thatthese nursing clothes can also be used for work, and Mamigaya's breastfeeding clothing products are marketed at affordable prices. prices between IDR50,000 to IDR 200,000.

Mamigaya's customers come from manybackgrounds, Mamigaya currently has marketingcovering almost all regions in Indonesia, and has penetrated foreign countries such as Singapore, Malaysia, the Netherlands and Germany who are interested in the Mamigaya model. Currently, Mamigaya itself has 13.9 thousand followers on one ofthe marketplaces, namely Shopee. The Instagram application Mamigaya has 51.2 thousand followersand 1,739 product photo posts posted on the first account, and has 23.8 thousand followers and 2,108 product photo posts posted on the second account.

### *2.2 Rapid Application Development (RAD)*

The Rapid Application Development method is an object-oriented approach that produces a system with the aim of shortening the processing time for applications and processes in order to empower the software system as quickly and accurately as possible (Tabrani & Priyandaru, 2021). RAD is development and part of SDLC is a software engineering methodology that focuses on building applications quickly and efficiently. This approach focuses on shorter development cycles, reusable components, and high-level development tools. RAD also emphasizes iterative development, enabling processes that are more flexible and responsive to changing user needs. To design an information system that takes at least 180 days, you have to go through stages that take quite a long time, so by applying the RAD method it only takes 30-90 days to complete the software system (Setyatama & Andrianto, 2018). This method emphasizes user involvement in the analysis and planning process so that it can meet user needs properly so as to increase system user satisfaction.

1) Analysis Quick Design: The first phase of RAD is understanding the system requirements of Analysis Quick Design.Requires a high level or knowledgeable end user to determine what the system function should be. So that it becomes a structured discussion about the business problem that needs to be solved. This phase of the process includes deciding what programming language and database to use. PHP scripts and MySQL database are used as development tools to develop prototypes. PHP itself is a scripting language that was originally designed to produce dynamic web pages. It has evolved to include command line interface capabilities and can be used in graphical applications. Also in this phase, theoverall structure of the software is determined. It is important to understand the system requirements before proceeding to prototype development (Abd Ghadas et al., 2015).

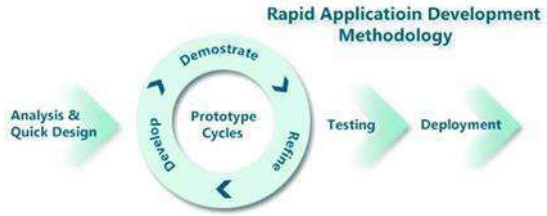


Figure 1: Diagram RAD (Abd Ghadas et al., 2015)

2) Prototype Cycles: The second phase is a repetition of the prototype development phase, namely development, demonstration, design. This includes creating the physical design for the database and mainly focuses on translating the design into programming code. The code for connecting from the programming language to the MySQL Database Management System (DBMS) was created (Abd Ghadas et al., 2015). 1) Demonstrate: This stage is the stage where the first prototype is made and shown to users to get initial feedback. This first prototype was created to test ideas roughly, and to determine what features needed to be improved or changed. 2) Refine: This stage involves perfecting the prototype after initial feedback is received. The prototype will be improved and modified based on feedback from the user, so that the prototype becomes better and fits the user's needs. 3) Develop: This stage is the stage where the refined prototype is developed into the final product. This stage involves programming and testing the application until the application is ready for release.

3) Testing: This stage is the application testing stage that has been built. In this stage, the application is thoroughly tested to ensure that it functions properly and meets user requirements. The trials include testing application functionality and testing user satisfaction. After the trial is complete, the application can be upgraded and improved according to the test results. The next process involves improving and correcting prototype errors. This stage is repeated until the prototype meets the research objectives.

4) Development: This stage is the final stage of software development. In this stage, the application is developed and refined according to the requirements and user feedback. After the application has been developed, it can be released and distributed to end users. However, app development doesn't end at this stage, as maintenance and improvements are usually required over the life of the app. RAD uses a number of tools and techniques to streamline the development process. This includes prototyping, iterative development, and component-based development. Prototypes allow developers to test early versions of applications quickly, so that user feedback can be integrated early in the process. Iterative development allows developers to create a basic version of an application and then gradually add more features and functionality. Component-based development allows developers to use reuse components and modules in different applications, making the development process faster and more efficient. Overall, RAD is an efficient and effective methodology for software development. This allows developers to create applications quickly and respond to customer needs (Kirmani, 2017).

### *2.3 Blackbox Testing*

Blackbox Testing is a software testing technique (Kusnadi et al., 2018). This method is used to determine the functionality of the application.

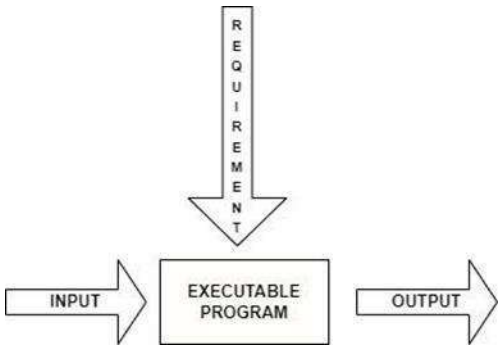

Figure 2: Black Box Testing (Viglianisi et al., 2020)

The main focus of Blackbox Testing is the input available to an application and the expected output for each input value. This test method is based on software requirements and specifications. It is a software testing technique in which the inner workings of the system under test are unknown to the tester. It is also called specification-based testing and behavior testing. This technique is so named because in this test, the tester does not need to know about the internal code of the application implementation. This test handles both valid and invalid input according to the customer's requirements (Viglianisi et al., 2020).

*2.4 Likert Scale*

The Likert Scale method is a method used to measure the level of user satisfaction using a Likert scale (Joshi et al., 2015). In this study, the Likert scale was used to measure user In this study, the Likert scale was used to measure user opinion on the website selling breastfeeding clothes that had been made. The following is the scale level and the score used (Table 1) :

Table 1: Scale Score of The Questionnaire

| No | Answer Choices | Score |
|---|---|---|
| 1 | Strongly Agree | 5 |
| 2 | Agree | 4 |
| 3 | Neutral | 3 |
| 4 | Don't Agree | 2 |
| 5 | Strongly Disagree | 1 |

*2.5 End-User Computing Satisfication (EUCS)*

End User Computing Satisfaction is an overall assessment of the use of information systems based on their experience in using the system (Abdinnour-Helm et al., 2005)(Santoso et al., 2023). End User Computing Satisfaction has 5 aspects which contain Content, Accuracy, Format, Ease of use and Timeliness.

1) Content: Measures user satisfaction with the content of the system. to fill the system usually consists of functions and modules that can be used by system users, as well as information generated by the system.
2) Accuracy: Measuring user satisfaction based on data accuracy when the system receives input, the system processes it as information.
3) Format: Measures user satisfaction in terms of appearance and system user interface aesthetics.
4) Ease of Use: Measures user satisfaction with the site's ease of use usage when using the system, data entry, data processing andsearching for the required data.
5) Timeliness: Measures user satisfaction with site accuracy system time in presenting or providing the information needed by the user.

## 3. Method

To complete the formulation of the problem that has been described previously, then below are thestages carried out in completing the research, namely:

1) Study of literature: Literature study is the initial stage in writing a research report. Literature study was conducted to obtain information and theories related to the RAD method and other supports, especially in terms of website design. Sources of information and theories needed in research can be obtained from scientificjournals, scientific papers, books, and interviews.
2) Analysis Quick Design: carried out by analyzing the needs planning process by conducting direct interviews with resource persons to identify problems and also collect the necessary data or recruitment and identify the ultimate goal or goals of the system and the desired information requirements. In this publication only part of the design is shown.
3) Prototype Cycles: At the prototype cycles stage, the design is made repeatedly if there is still a design discrepancy againstthe required requirements that have been identified in the first stage beforehand.
4) Testing stage, continuing development and integration by considering feedback from users or regarding designs that have been made and turning them into beta applications. If the process goes smoothly then it can proceed to the next stage, meanwhile if the application to be developed does notmeet the requirements, the developer returns to the system design stage.
5) Development: At the development stage, implementing thesystem design on the beta application that was tested in the previous stage and has received approval from the user. Before the system is implemented, the program first undergoes a testing process where errorsin the system to be developed are detected. At this stage, usually provide feedback on the system being built and seek approval for the system.
6) Report: At this stage of writing the report will cover all theresearch that has been carried out from the initial stagein the research, namely the study of the literature to thedevelopment carried out, then the conclusions and suggestions resulting from the research that has been carried out.

## 4. Implementation

Figure 3 is a sitemap of the page used for the customer panel. Customers can access the entire panel by logging in first with their registered email and correct password in the database. If a customer does not have an account, they can register on the create account page. Once the customer successfully logs in, they can add items to their shopping cart and proceed with the ordering process.

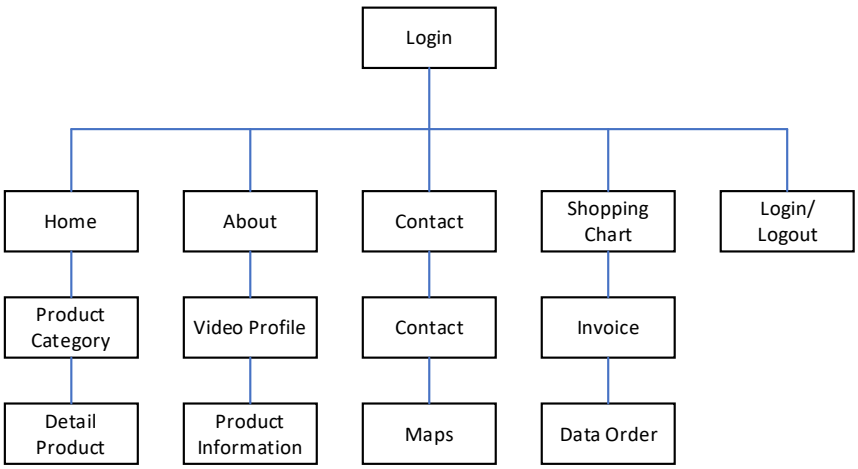


Figure 3: Customer Site Map

In this website design, a use case diagram is needed to illustrate the activities performed by actors within the system (Figure 4).

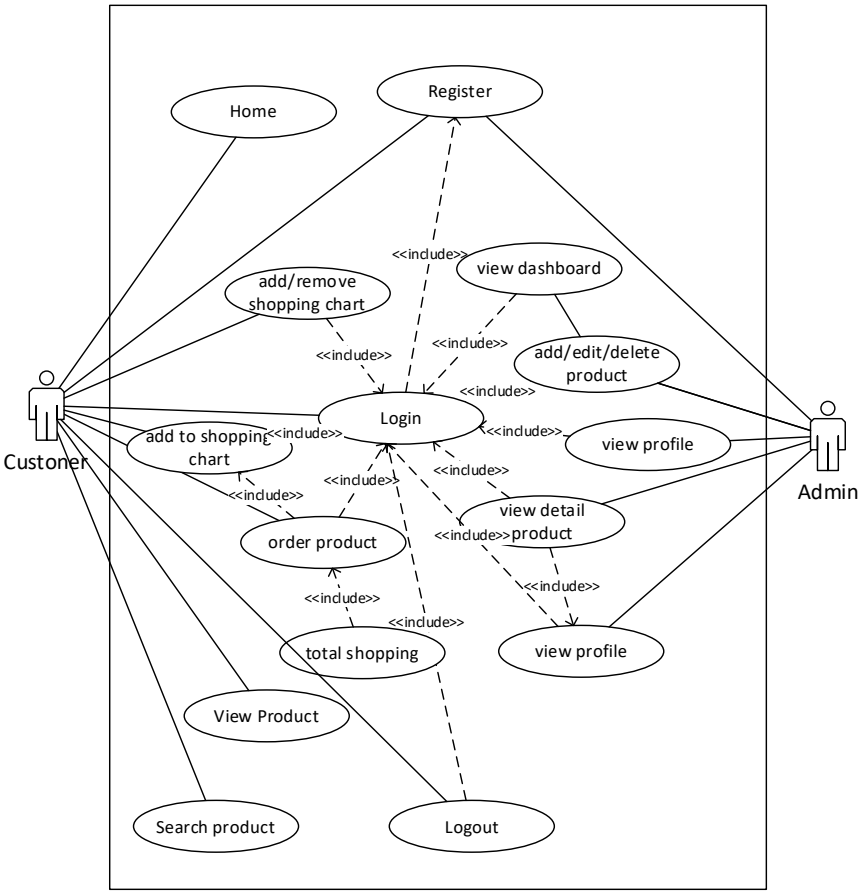


Figure 4: Use Case Diagram

*4.1 Development*

The implementation of the application of the rapid application development method in web design selling breastfeeding clothes at Mamigaya is using the code igniter framework and SQL database. It accessible at the link https://mamigaya.online. The systemis made in the form of a website with 2 actors namely admin and customer. The login page is used by admins and customers to be able to enter the system by filling in an email and password. The implementation of the login page is shown in Figure 5.


Figure 5: Login Page

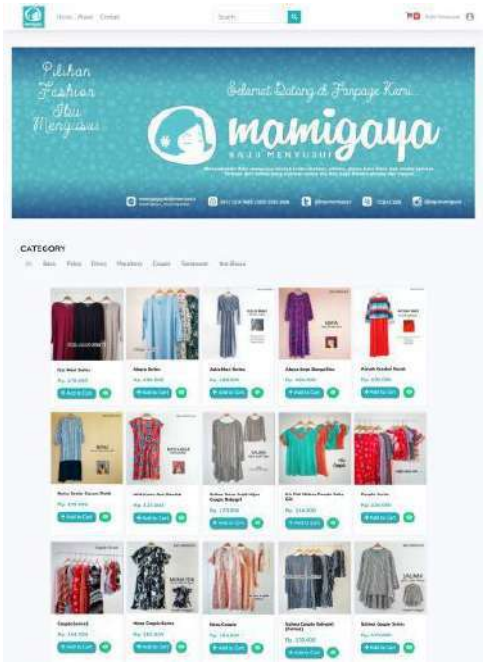


Figure 6: Home Page

*4.2 Development*

The home page is the main page of the website. Infigure 6 the customer can see the products displayed on the website. However, when the customer wants toadd a product to the cart, the customer is required to log in first, when the add to cart button is clicked it will display a message modal to log in first.

*4.3 Testing*

Test blackbox testing by testing all the features on the website with the result that the features can function as they should. The user satisfaction test is carried out bydistributing online questionnaires to users who have tried the online shop website. User satisfaction test forthe application of the rapid application development method to website design selling breastfeeding clothesat Mamigaya uses the End-User Computing Satisfaction (EUCS) method. The EUCS method has 5 main factors that form thebasis for compiling a user satisfaction questionnaire. Table 2 show the result of survey:

Table 2: The Questionnaire Results

| Aspect | SS | S | N | TS | STS |
|---|---|---|---|---|---|
| Content | 23 | 10 | 4 | 0 | 0 |
| Accuracy | 21 | 10 | 5 | 1 | 0 |
| Format | 17 | 13 | 6 | 1 | 0 |
| Easy of Use | 24 | 9 | 3 | 1 | 0 |
| Timeliness | 18 | 12 | 6 | 1 | 0 |

The first question got 37 respondents, 23 people answered strongly agree, then 10 people answered agree, and 3 people answered neutral. Same explanation for the other question. After getting the results of the total preset for eachquestion, then then calculating the overall results of the percentages to be able to find out the total overall score of all EUCS factors. Based on the results obtained from the percentage calculation, it can be concluded that the answers of allrespondents to the question about the 5 factors inEUCS achieved a total score of 88.58%. This shows that respondents strongly agree with the results ofapplying the rapid application development (RAD) method in designing a website selling breastfeedingclothes.

## 5. Discussion

Implementing Rapid Application Development (RAD) on an e-commerce website can offer several advantages, though it requires careful consideration and planning to ensure success. Here's a discussion on implementing RAD for an e-commerce website:

- Speedy Development: RAD enables rapid creation of an e-commerce website by building quick prototypes. This allows businesses to enter the market faster or respond swiftly to changing trends.
- User Involvement: RAD involves stakeholders and users at every development stage. This facilitates valuable feedback, leading to a solution that better aligns with user needs.
- Flexibility: The RAD approach allows for easy changes and adjustments during development, making the solution more responsive to evolving needs or customer requests.
- Iteration: The ability to create prototypes and iterate quickly aids in refining and enhancing website functionality incrementally.
- Improved Quality: Through continuous iterations and feedback, the final solution has the potential to be of higher quality and functionality.

Considerations:

- Complexity: While RAD speeds up development, neglecting proper planning and analysis can lead to complexity issues later on.
- Scalability: While RAD is suitable for generating initial prototypes and solutions, consideration must be given to how this solution will be scaled into a larger, more scalable e-commerce platform.
- Code Quality: Rapid development can lead to subpar code quality if not managed properly, which might result in security and performance issues down the line.
- Intensive User Involvement: The RAD process involving heavy user participation may demand more time and effort from both developers and users.
- Maintenance: Without proper management, rapid iterations can pose challenges in terms of maintenance and documentation.

Implementing RAD for an e-commerce website can be a highly beneficial approach if executed well. However, it's important to follow best software development practices and consider potential challenges along the way.

## 4. Conclusion

The results of testing this website are carried out by distributing questionnaires, on this website a system test is carried out using the black box testing method to see whether the functionality of the developed website is working properly or not. Then the website has also been tested for user satisfaction, the results of the questionnaire that has been distributed are calculated using the end-user computing satisfaction method and the final total percentage score can reach 88.58%, which means the user strongly agrees with these breastfeeding clothes sales website. Thus, can it was concluded based on theresults of the discussion of the conclusions of the RADmethod from the system testing stage with the black box testing method and testing user satisfaction with EUCS, that the application of the RAD method to website design selling breastfeeding clothes at Mamigaya was successfully carried out.

## Acknowledgments

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# Groundwater Nitrate Pollution Assessment in Warangal

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**Abstract**
Due to nitrogen fertilizers consumption and unsafe wastewater networks of cities, now nitrate pollution is one of the challenging issues of surface and groundwater pollution. In case of this contaminant present in drinking water causes 'Blue Baby' disease for infants, cancers, and harmful for pregnant women. So, it is very important to assess nitrate concentration for maintaining better health precaution. Nitrate concentration, dispersion and its distribution status were evaluated in Warangal District, India. The samples show that nitrate concentration in Warangal is very high in both urban and agriculture area which have maximum level of 49.5 & 83.3 mg/ liter as (NO3 – N); average value of 40.3 and 69 mg/l respectively. Even though in urban area the amount of concentration is somehow low, but it also is in harmful level. Nitrate dispersion could be observable from the high standard deviations which are 7.4 for urban area and 12.065 for agriculture area, it means nitrate dispersion in agriculture area is more than urban area's groundwater and it is clearly observed from normal distribution curves. This high spread out on nitrate concentration shows many variations of nitrate sources from many different locations that various amount of nitrate pollutions is infiltrated into groundwater.

**Keywords:** Nitrate Assessment, Groundwater, Warangal, Urban, Agriculture, Dispersion and Normal Distribution

## 1. Introduction

One of the worldwide big concern is the water pollution, many people are there in developing country which is suffering from un-safe water. Recently, due to improper uses from N- fertilizers for agriculture and inappropriate urban plans to manage the wastewater collection and management properly, large scale of nitrogen as nitrate pollution have been infiltrated into groundwater. Since, water is the most primary need for mankind, unsafe drinking water would cause irreparable crisis. More than one billion people in developing countries don't have clean water for drinking (Gosling and Arnell, 2016). The reason which groundwater nitrate pollution is increasing very fast in China is using large quantity of N – fertilizers in agriculture area (W.L. Zhang *, 1996) . In Japan, during the last two decades researchers shows that many areas have high nitrate pollution in groundwater which some of them are used for drinking water (Kumazawa, 2002). Kumazawa says in his research that among 1362 wells, 64 wells are used for drinking water which their standard limits are more than

acceptable amount. 76% of world population are living in developing countries, as well as use of N-fertilizers are more than developed countries (Bijay-Singh *, 1995).

Most of people who don't have access to safe drinking water are living in developing countries (Gosling and Arnell, 2016), and According to UNICIF and WHO (2015), majority of the people who have not access to safe potable water are living in Asia and sub-Saharan Africa. Meanwhile, United Nations organizes several targets in the Agenda 2030 for Sustainable Development the major source of water is supplied for people is groundwater which is used as private wells. In many places, because of urbanization, industrials and agriculture activities water is polluted with pathogenic and anthropogenic pollutants. From inorganic or anthropogenic pollutants, we can mention nitrate and nitrite pollution in water.

Water nitrate pollution has different sources like agriculture area, industrial, urban area (wastewater and solid waste) which are in filtered into groundwater table. Nitrate is the stable form of nitrogen in the nitrogen cycle and has an unreactive character. Methaemoglobenia disease is the major health risk of nitrate exposure through drinking water that is called "blue baby syndrome," especially it is a big threat for infants as well as for pregnant women. Due to the nature of the infant digestive system, nitrate is reduced to nitrite which can render hemoglobin and causes that oxygen cannot reach to body cells (SWRCB 2010). Small rural communities are particularly impacted by nitrate (Pacific Institute 2011), recent studies have suggested that it can cause cancer in humans as well (Chiu et al., 2007; Kumar et al., 2009; Meenakshi and Viswanathan, 2007). In nitrate concentration be higher thang 300 mg/liter, it can be problematic for animals also (Islam and Patel, 2010).

In Warangal district less researches was done related to groundwater nitrate pollution. (Narsimha. A1, 2012), studied on groundwater nitrate pollution and the results what they got are between 6 mg/l to 100 mg/l as nitrate with mean value of 39.44 mg/l. meanwhile they say that among the all samples 61% of samples were suitable for drinking purpose, it means that 61% of samples had concentration less than standard limit (50 mg/l). In 2013 Central Groundwater Board, Groundwater Brochure, Warangal District, Andhra Pradesh have done a research on Warangal district groundwater quality, nitrate concentration which is got in this research is equal to mean value of 150 mg/liter and maximum value of 850 mg/liter as nitrate.

Again Central Groundwater Board, ground water year book 2016-17 Telangana State, have done a research on Telangana State groundwater quality. In this research the nitrate concentration which they obtained is in the range of (0 - 506 mg/liter), the maximum concentration was detected in Ippagudem well (Warangal district) among the 392 samples. What we obtained from aforesaid paragraph, nitrate concentration in Warangal district is increasing. Increasing nitrate pollution in groundwater is due to different sources raise the groundwater risk day by day and world widely is spread (Mattern, Fasbender, & Vanclooster, 2009); (Simpkins S. , 2001); (BUROW, 2010) . Over last decades the because of using much N-fertilizers for crops yield are increasing.
The objective of this study is to evaluate the nitrate concentration of particular areas in Warangal district, Telangana state, India and also study of dispersion and distribution situation of groundwater nitrate in the area with the connection to sources of nitrate which agricultural and urban was considered significant source of nitrate here. So this study covers which groundwater nitrate should be concern about agriculture or urban, and how is the distribution status in both areas and how much we should be concern about the groundwater nitrate situation in Warangal district.

## 2. Materials and Method

Totally 20 groundwater samples were collected from two different nitrate pollution sources agriculture (Paindipaly village) and urban (around thousand Pillar; Hanamkunda) areas, 10 samples from each one. The water samples collection was done using plastic bottles, and within 3 hours the samples were reached to laboratory and tested after passing Whatman No 40 filter paper.

The test was done by Microprocessor UV-VIS Double Beam Spectrophotometer (Model: LI-2800) using Standard Method (Arnold, 1992) for nitrate determination which using 275 nm and 220 nm wavelength absorbance are determined and then for correction of absorbance the absorbance of 275 nm was subtracted from 220 nm. Nitrate has more absorbance in the presence of 220 nm, and more absorbance shows more

concentration. First of all, using $KNO_3$ salt stock solution was prepared, and using stock solution standard solution was provided, and then using Absorbance against Nitrate concentration which was already known the standard curve was drawn (4500-$NO_3$– B. Ultraviolet Spectrophotometric Screening Method**)**. The samples unknown concentrations were determined, after finding their absorbance were determined via standard curve (figure 1.1).

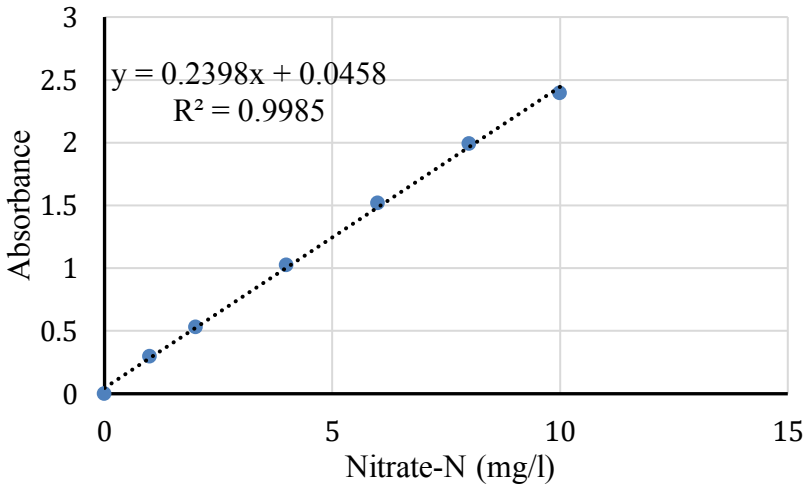


Figure 1.1: Nitrate determination standard curve (Arnold et al, 1992).

In order to know how the pollution is distributed normally and find the variation of dispersion status of nitrate pollution in mentioned areas, parameters like standard deviation, mean values, median, skewness and kurtosis was needed. Therefore, for these purposes SPSS software was used for statistical analysis to predict how is the situation of nitrate pollution dispersion in study area. By calculation and prediction of groundwater samples using SPSS probability density of nitrate was calculated in groundwater which standard deviation and mean values are the significant indicators, and good determiner for dispersion and have important role for normal distribution shape.

## 3. Results and Discussion

### *3.1. Nitrate determination*

Based on objective of the study, groundwater nitrate concentration was determined, and the dispersion situation was statistically analyzed in both areas. For more or better accuracy nitrate determination was done five times (n=5) for each samples and then mean values are calculated. Table 1.1 & 1.2 show the results of nitrate concentration in both sources of nitrate pollution. It is noticeable that nitrate concentration expressed in the form of nitrate- nitrogen ($NO_3$ – N).

Table 1.1: Nitrate concentration in groundwater of agriculture area (n=5).

| No | Area Name | Depth of the well (m) | Mean (n=5) (mg/l) as $NO_3$-N |
|---|---|---|---|
| **1** | Kokthepet | 50 | 56 |
| **2** | Kokthepet road | 44 | 69.6 |
| **3** | NSR School | 67 | 78 |
| **4** | Arpally | 40 | 81.2 |
| **5** | Arpally, North side 1 km farther | 34 | 82.9 |
| **6** | Bacharlagadda | 83.3 | 68.8 |
| **7** | Near agriculture college (1) | 83.3 | 83.3 |
| **8** | Near agriculture college(2) | 135 | 59.6 |

| | | | |
|---|---|---|---|
| **9** | Arithral village (1) | 130 | 60.2 |
| **10** | Arithral village (2) | 150 | 49.9 |

Table 1.1 represent that nitrate maximum concentration is 82.9 and the minimum value is 49.9 mg/ liter as ($NO_3$ – N), and among these ten samples which were collected from different agriculture area in Paidipally village are not in acceptable limit as per WHO drinking water norms. Compare to standard limit which WHO is determined for nitrate in drinking water is equal to 11.3 mg/l as ($NO_3$ – N), whereas the minimum concentration in mentioned area is 49.9 mg/l which is almost five times more than acceptable level. when we attend on results from urban area, nitrate concentration in urban area is low compare to agriculture area, but it is also more than standard limit see Table 1.2.

Table 1.2: Nitrate concentration in groundwater of Urban area (n=5).

| No | Area Name | Depth of the well (m) | Mean(n=5) (mg/l) as NO3-N |
|---|---|---|---|
| **1** | Thousand Pillar Temples | 37 | 42.1 |
| **2** | Mahli Bazar (1) | 42 | 40.5 |
| **3** | Mahli Bazar (2) | 43.3 | 39.1 |
| **4** | Mahli Bazar (3) | 47 | 37.23 |
| **5** | Reddy Colony urban area (1) | 67 | 32 |
| **6** | Reddy Colony urban area (2) | 55 | 48.7 |
| **7** | Padmakshi, Vivekananda High school | 83.3 | 35 |
| **8** | Padmakshi | 57 | 49.5 |
| **9** | 1.8K hostel back side bore well (NITW) | 67 | 36.54 |
| **10** | Thousand Pillar temples (2) | 41 | 40.23 |

As it is seen, nitrate concentration in urban area is very low compare to what has been fallen in agriculture area. The maximum and minimum values are 49.5 and 32 mg/l respectively in urban area. By observing the results of nitrate concentration in two different groundwater nitrate pollution source, eventually we could write that agricultural nitrate pollution source are significantly release pollution more than urban nitrate pollution source in groundwater. The reason for agricultural area would be much overuse of Nitrogen- fertilizers for increasing of crop yielding, and from other hand most of farmer may without technical training use extra fertilizers which the crop or plants roots are not able to catch that much nitrogen, so the additional nitrogen after long time reach to groundwater in the form of nitrate.

*3.2 Nitrate Dispersion and Distribution Analysis*

In order generalize the results what are obtained above, some statistical calculation was done using SPSS, and the probability density was determined in each area which represent how the nitrate pollution is distributed in both area and how much difference are between? Probability density shows dispersion situation and normal curve distribution. The dispersion situation and normal curve shape and status depend on two very important indicator factors which call standard deviation and mean. Here the analysis was done in two phase. Once, each one area was studied individually and then considered the results of both areas in combination to have larger scale of study area.

3.2.1. Phase 1 (Individual Analysis)

In this phase each nitrate pollution source was analyzed individually, two Nitrate concentration and source of nitrate were variables of the analysis. According to these two variables, dispersion was evaluated standard deviation and mean value which are the significant indicators of dispersion were calculated, and simultaneously the curve of normal distribution was drawn as well to figured out a clear picture from nitrate dispersion in the mentioned area, see (Figure 2.1) which represent the nitrate status in urban area groundwater.

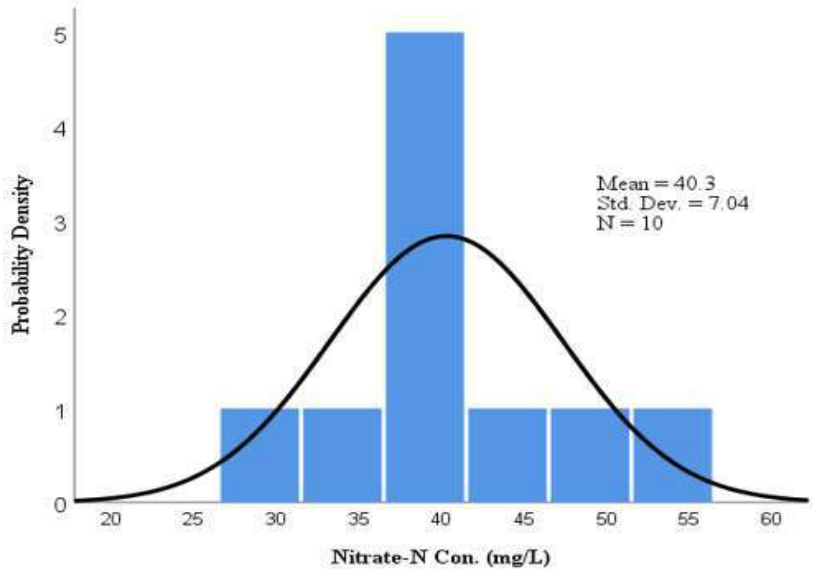


Figure 2.1: Histogram graph of groundwater nitrate concentration in urban area (Thousand Pillar), Warangal City.

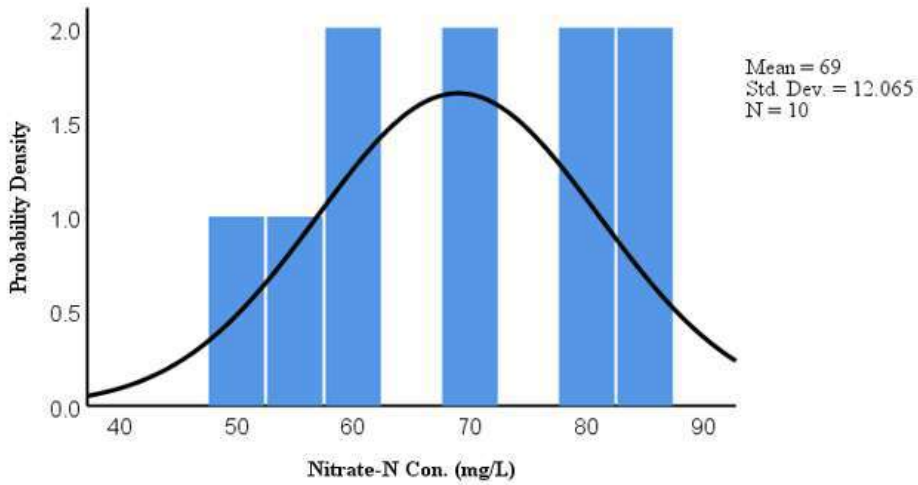


Figure 2.2: Histogram graph of groundwater nitrate concentration in agriculture area (Paid paly), Warangal District.

From figure 2.1 & 2.2, it is obviously observed that standard deviation and mean values in urban nitrate source is significantly low compare to agricultural area, even though, 7.04 standard deviation is a big value, and shows high dispersion of nitrate pollution in urban area. According to three Standard Deviation Rule (68%, 95%. 99.7%), which is started with 68% from mean point and spread out through 99.7%. It is spread both side based on standard deviation valu. As much as standard deviation and mean value are less, accordingly dispersion is less, and vis versa as much as standard deviation and mean values are high, in same proportion, dispersion is more. Therefore, since standard deviation and mean values in urban area are low against agriculture area, we infer that groundwater nitrate dispersion in urban area is lower than agriculture area which has standard

deviation equal to 12.065 and mean value of 69 mg/l. it means, agriculture area has larger interval of SD which shows more dispersion (figure 2.3)

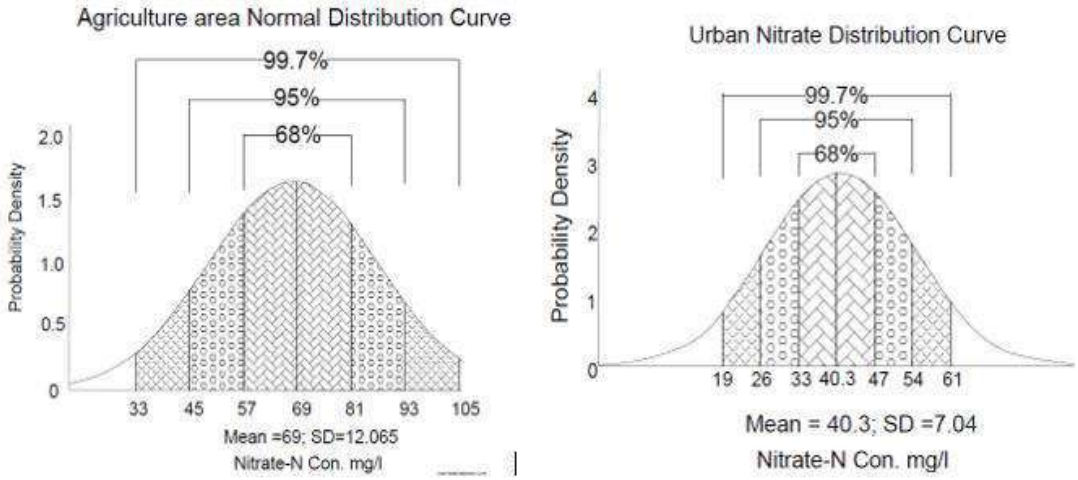


Figure 2.3: Nitrate Normal Distribution Curve and dispersion situation of both study areas.

Eventually, everything is clear form figure 2.3 that more dispersion was happened in agriculture area than urban area, and have more mean value also which expresses its concentration is also more than urban area as well. It is clearly visible that the amount nitrate concentration in agriculture area which include 68% is from 57 to 81 mg/li, whereas in urban area 68% is including of 33 to 47 mg/l of nitrate concentration, dispersion is almost two times more than urban area. The reason that agricultural nitrate source is more dispersed than urban areas are would be depend on the amount on nitrogen which release in groundwater. In agriculture area from everywhere of agriculture land the extra nitrogen is infiltrated into groundwater without any slightest control, but vis versa in urban area as much as possible people are trying to prevent the nitrogen infiltration into groundwater by providing wastewater networks or individual prevention.

3.2.2. Phase 2 (Combined Analysis)

The reason of considering as combine was to see the nitrate dispersion and distribution in a larger scale area of groundwater which include both urban and agriculture sources, Figure 2.4 shows the result of combine areas.

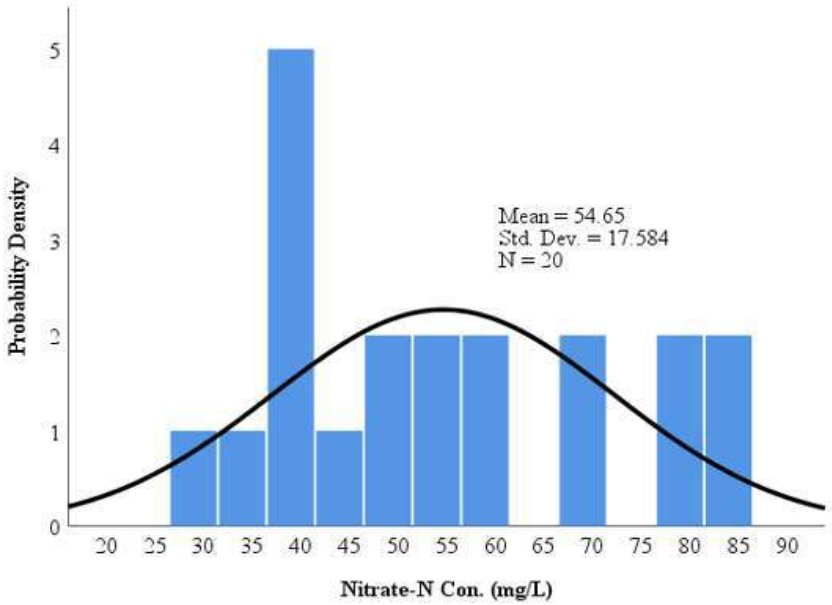


Figure 2.4: Nitrate concentration Probability density distribution and combine normal curve in Paid paly and Thousand pillar.

When the results of both sources were analyzed as one source, the obtained result is totally different compare to individual analysis, because here large area was investigated and from other hand two different source was considered as one object. Here probability density lower than urban area and higher than agriculture area and also the mean value, but standard deviation is very high. I might be due to increasing the number of samples and also combination causes. Since the number of sample were less, may be the analysis have its error, but should not forget that can give a very good perspective about the nitrate situation and its distribution in the to us. Finally, it is concluded that high standard deviation in agriculture area is due to nonhomogeneous of nitrate in groundwater because each crop land has its own infiltration which is dramatically high, so it could be one of the reason that in agriculture area much difference be between one point to other point. But in urban area since the nitrate source is poor and also is tried to prevent from infiltration using different way, it is caused homogenously. When it is considered as combine, the mean valued was reformed a bit, but standard deviation was increased, so the nitrate concentration in urban areas was low and in agriculture area was high and in increased the standard deviation which shows high dispersion.

## 4. Conclusion

This study shows that the groundwater in Warangal district from nitrate pollution point of view is in critical situation. Although, this study was done in small scale area, but it could be a good instance to show for us what is the state of nitrate pollution of groundwater in the area. From previous research it is known that nitrate pollution is increasing when it is compared with this study. The reason for high dispersion is might be overuses of N-Fertilizers and beside this unsuitable wastewater network would be there, which have remarkable infiltration into groundwater from each different points. So generally it concluded that both urban and agriculture areas are the sources of nitrate which can pollute considerably the groundwater, and it suggested to prevention should be taken, otherwise it might be cause a large problem for drinking water and water treatment technologies

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# The Effect of Copper Mineral, Copper Sulfate and Copper Nanoparticles on Fish

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**Abstract**
Copper is a mineral element that is widely found in nature and is very important for humans and aquatic animals as an essential element for the growth and development of fish and also in the activity of biochemical enzymes and in processes such as blood production, immune system, The production of energy molecules and salt water balance plays an important role in the fish body. Its deficiency in water can lead to growth and health problems in fish. Its compounds, such as copper sulfate and copper nanoparticles, can have various effects on fish. Copper sulfate is usually used as a source of copper in fish feed. Its consumption in nutrition can improve the growth of fish, strengthen the structure of bones and maintain their immune system. However, too much copper sulfate can be toxic and cause problems such as skin irritation, discoloration, scratched gills and even fish death.

**Keywords:** Aquatic Animals, Copper, Compounds, Growth, Nanoparticles, Sulfate

## 1. Introduction

Following the increase in population and meeting the growing need for human food, the use of aquatic resources has increased as a source of protein needs. In the meantime, fish have a significant role in providing the nutritional needs of humans and the health of their heart, body and mind with a significant amount of vitamins, minerals and fatty acids (Gheysari, 2016). Today, attention has been paid to the production and breeding of freshwater species, and based on the forecasts made by FAO, it seems that approximately 60% of the share of aquaculture products will be included (FAO, 2016). The cost of feeding in aquaculture usually includes more than 60% of the total costs. Therefore, to achieve successful aquaculture, it is necessary to use the appropriate food ration in such a way that all the nutritional needs of the fish are provided in different conditions of the breeding environment. For this purpose, in addition to being fully familiar with the needs of different types of aquatic species, fish breeding specialists should also be aware of food analysis in order to be able to adjust rations according to the needs of aquatic animals. In recent decades, keeping aquarium fish has become one of the most popular pastimes of mankind (Wu *et al*., 2010). In this regard, aquaculture has turned to new technologies in order to increase the growth and efficiency of fish feeding, as well as to find natural and

inorganic antibacterial methods and compounds to control disease-causing agents. Among these, nanoparticle technology has received special attention as one of the most effective antibacterial methods and compounds, and has created a suitable opportunity for the development of the aquaculture industry, which should be considered with its advantages and disadvantages (Kim *et al.*, 2007). Minerals are among the most important components of the aquatic diet, which are separated from other nutrients by their main components and inorganic nature, and many of these elements are important due to the existence of structural and metabolic functions in the body of organisms (Davis and Gatlin, 1996). Despite conducting research activities in the field of aquatic nutrient requirements since the 1950s, research on mineral substances began in the mid-1970s and has been progressing slowly until today (Prabhu *et al.,* 2016). Copper element is considered as a necessary mineral in the nutrition of aquatic animals and the dependence of the physiological reactions of aquatic growth on the activity of copper-containing enzymes necessitates the continuous need for copper in the diet. According to the presented studies, organic copper or copper in the form of nanoparticles has more biosupply compared to mineral copper and if the particle size of large copper molecules is reduced to the size of nano particles, small molecules can be easily absorbed from the intestine and as a result copper is digestible. It increases in the digestive system. Also, unlike the antibiotics and chemicals used that cause sensitivity in the patient's fluid or resistance caused by mutation in the pathogenic agent, it seems that nanoparticles are stable antimicrobial agents that do not cause resistance in pathogenic agents. On the other hand, it should be noted that different types of nanoparticles, such as copper nanoparticles, act as stimulants or inhibitors of growth and immunity based on their amounts in biological processes; therefore, special attention should be paid to the amount of their use in the diet of different aquatic animals.

## 2. The importance of growth and nutrition in fish

Growth is seen as an important goal in aquaculture in the form of significant changes in characteristics such as length, weight and even energy levels of fish. Living organisms in biological processes, for biochemical interactions that lead to tissue construction and to maintain water and salt balance. Movement of food along the digestive system, digestion and absorption of food, air breathing, reproduction, movement and to maintain their health, they need energy (Silva and Anderson, 1995). Creating energy through the oxidation of various fats, the glycogen reserves in the body, the breakdown of protein compounds into smaller components, and the oxidation of organic compounds in the diet takes place after the consumption of food and the processes of digestion and absorption of food (Kaushik and Seiliez, 2010). Many factors are effective in the process of growth and energy acquisition, one of the most important of which is feed and nutrition management (Caruso *et al.*, 2009). Many physicochemical factors such as temperature, oxygen level, light, ammonia nitrogen and salinity along with biological factors such as gender, species and density of farmed fish and even the amount and type of fish activity by affecting the appetite and eating of fish, indirectly influence the growth. They put (Cuenco *et al.,* 1985). Studying the nutritional needs of different aquatic species leads to the improvement of the formulation of food rations with the optimal balance of nutrients to improve the growth rate of fish, increase their health and quality, and finally, success in intensive breeding. In the past decades, many studies have been carried out in order to achieve the proper formulation of food rations with the aim of producing high quality commercial food rations (Aprodu *et al*., 2012). Since the use of formula food is for 72.3% of the species that are cultivated in fresh water (FAO, 2012). Therefore, farmed fish in closed circuit or super dense systems should be fed with a high quality and complete diet in terms of nutrients in order to achieve rapid growth of aquatic animals (Nasopoulou *et al*., 2014). Therefore, it is necessary to understand the appropriate information in the field of biological and nutritional needs of the breeding species, which is an important matter, to make a balanced and optimal formulation of the food ration with proper quality control and also to provide all the nutritional needs of the fis (Aprodu *et al*., 2012).

## 3. Importance of minerals in fish diet

Minerals are among the most important components of the aquatic diet, which are separated from other nutrients by their main components and inorganic nature, and many of these elements are important due to the existence of structural and metabolic functions in the body of organisms (Davis and Gatlin, 1996). The role of minerals in the body can be divided into structural, physiological, catalytic and regulatory functions; Minerals form the structural components of organs and tissues of the body and can also play a role as a part of the membrane in the

stability of the structure of molecules and control the reproduction and differentiation of cells. These substances are important in body fluids and tissues as electrolytes to maintain osmotic pressure, acid-base balance, membrane permeability and nerve message transmission. In addition, they act as catalysts in enzymes and endocrine systems and play a role in the structure of metalloenzymes, hormones and activators (coenzymes) (Prabhu *et al*., 2014). The role of minerals in nutrition, physiology and life of many living organisms has been studied. However, access to information on the mineral requirements of fish and their effects on the biochemical composition and function of the body, enzymatic reactions and non-enzymatic structural units is limited. Despite conducting research activities in the field of aquatic nutrient requirements since the 1950s, research on mineral substances began in the mid-1970s and has been progressing slowly until today (Prabhu *et al*., 2016). In addition to the limited access to information on the minerals needed by fish compared to other food groups, there is little information about the mineral requirements of aquatic species compared to land animals, and the reason for this is the absorption of these elements by fish through water and It is food (Stickney, 2000). In general, the assessment of the mineral elements needs of fish is much more complicated than that of terrestrial organisms due to interactions with the aquatic environment (Kaushik and Seiliez, 2010). Biological parameters such as the species of the farmed fish, the stages of life or sexual maturity in which it is located, its habit, level and nutritional status, signs of lack of elements in the body, diet compositions and some parameters of the breeding environment such as the concentration of substances in the water, salinity, Temperature, type of rearing system and other factors such as body mineral content, ion stability and regulation, material concentration in tissue, plasma, activity of different enzymes, excretory secretions and even gene expression related to different mineral elements can be useful in determining mineral levels. to occur (Jobling, 2012).

**4. Importance of copper mineral in fish diet**

Copper is a rare vital element in the diet of animals, however, it cannot be stored in the body. In addition, animal feed ingredients are copper-free; Therefore, commercial food should provide the necessary amount of copper in a biologically energetic form, which depends on the physical and chemical properties of the supplemental form that is added to the diet. Copper, as an essential mineral in aquatic nutrition, is an important compound in enzyme systems that plays a vital role in oxidation-reduction activities. Copper is present in the combination of cytochrome oxidase, tyrosinase, superoxide dismutase, amine oxidase, lysyl oxidase and ceruloplasmin enzymes. It also seems that the presence of copper element is necessary for the formation of melanin and skin pigments, the formation of bones and connective tissue. It is a part of the heme part of the hemocyanin of crustaceans, a cofactor in tyrosinase and acidoscubic oxidase (Lall and Milley, 2008). The copper mineral element or its compounds act as growth and safety stimulators or inhibitors based on their amounts in biological processes. It has been reported that using a suitable source or a form of mineral material that has more biosupply can be a way The appropriate solution to reduce the consumption of rare minerals in their food and nutritional ration should be more. The use of compounds containing copper in the appropriate amount and in the amount needed by aquatic species in the diet increases the digestibility and absorption of copper in the body, reduces its accumulation in aquatic waste and environmental pollution, and leaves favorable antimicrobial effects in the digestive system. The presence of sufficient amounts of copper element in the body causes the exocytosis of the lysosome of the liver cells, the release of the copper in the liver into the bile and the stimulation and increase of bile glucosidase secretions. Finally, it leads to facilitating and improving the digestion of carbohydrates, increasing apparent metabolizable energy, improving feed efficiency, and finally increasing growth performance (Akinsanmi and Igbasan, 2012).

**5. Different effect of copper mineral on fish**

Food ration is the main source of copper supply for optimal aquatic growth. Copper is absorbed through the intestinal epithelium (anterior half of the intestine) and gill appendages (Taylor *et al.,* 2007). The dependence of the physiological reactions of aquatic growth on the activity of copper-containing enzymes necessitates the continuous need for copper in the diet. Aquatic nutritional changes somehow cause changes in the ability to consume copper and more fluctuations in delivering copper to tissues. Following the decrease in the amount of dietary copper in the body, first the copper reserves in the body decrease, and as a result, the emptying phase, and then the deficiency phase occurs, in which only the main copper-dependent reactions are maintained, while the copper is released from the reserves along with absorbed copper. It does not seem to be enough to stabilize

the serum copper concentration in the normal range. After this stage, a state of disorder occurs when one or more of the physiological reactions related to copper are damaged, and in the last stage, a disease occurs, which is the clinical manifestation of the disorders. The lack of this element in the aquatic body causes disruption in the collagen bond and bone structure and increases bone fragility (Papagiannis, 2004; Eisler, 1998). The amount of water need for copper depends on the physiological conditions, the type of species, the copper content of the water and the amount of zinc, cadmium, iron and molybdenum ions in the food, which are all copper metabolic antagonists (Kamunde *et al*., 2002). Unwanted excretion of copper is through urinary secretion, feces and skin, because when dietary copper is low, some copper is excreted despite the body's need. When the absorption of copper is more than needed, its excretion is necessary for copper balance in the body. It has been proven that many of the changes caused by copper deficiency are due to the decrease in copper-dependent metalloenzymes. The physiological state of the cells during the emptying phase affects the intensity of the effects of these defects, biochemical defects produce different effects in specific cellular lesions, which are different effects due to cellular kinetics. Also, copper deficiency may increase if there are functional defects in other tissues (Arthington, 1996; Tabinda *et al*., 2010). Of course, it should be noted that although this element supports the physiological processes of aquatic animals, it has an inhibitory and toxic effect in concentrations higher than the aquatic requirement (Rainbow and Furness, 1990). Also, excessive amount of copper in aquatic feed can have negative effects on intestinal morphology and increase the rate of apoptosis and cell division in intestinal cells. Copper, in the amount of 3 to 11 mg per kilogram of diet, is a necessary element in the feed of most aquatic species. It should be noted that the amount of copper needed is different among different species and it may even be different in different stages of the same species. Using 3 milligrams of copper per kilogram of food ration increases the growth of common carp and rainbow trout. In an experiment, rainbow trout fish were fed a diet with low copper (0/8 micrograms per gram of fish weight) and also in water with low copper0/73. Micrograms per liter were placed; which caused a sharp decrease in growth in the period of 50 days. The dietary requirement of copper in catfish does not exceed 1/5 mg and shrimps do not exceed 25 mg per kilogram of food ration. The nutritional toxicity threshold of copper element for channel catfish in a daily dose higher than 1 mg per kilogram of body weight, for Atlantic salmon depending on the life stage is 1 to 11 mg per kilogram of body weight per day and for colored trout. It is 44 milligrams per kilogram of body weight per day. Also, Mohsenii et al., 2012, concluded in their studies that the need of baby elephant fish for copper element in the diet is 10-13 mg per kilogram of diet. Adding 8 and 16 milligrams of copper per kilogram of food ration, which is 2 and 3 times the sufficiency level of tilapia fish, respectively (Shiau and Ning, 2003). (And channel catfish) (Gatlin and Wilson, 1986). It caused a decrease in the growth of these fish. Lack of copper strongly changed the development of zebra fish embryos (Lundebye *et al*., 1999).

**6. Effects of copper sulfate on fish**

Copper sulfate is a non-mineral compound whose chemical composition consists of copper, sulfur and oxygen. Its chemical formula is $CuSO_4$ and it is also known as blue cut. This substance is widely used as a disinfectant compound to prevent fins from rotting. Copper sulfate, which is the most common form of this material, is light blue in color and is produced industrially through the electrolysis of copper metal with concentrated sulfuric acid or copper oxide with dilute sulfuric acid. Copper sulfate, an odorless crystalline substance, light blue in color, is toxic and can destroy pathogens such as bacteria, fungi, etc. Skin damage, as well as preventing the entry of external parasites into aquariums are used in freshwater fish. The toxicity of copper sulfate depends on the amount of copper in it and causes kidney necrosis, destruction of hematopoietic tissue, increase in liver fat, and inhibition of some digestive enzymes in fish. Therefore, the amount used should be adjusted according to the hardness of the water based on 0.25-3 ppm of copper ions. Although the use of copper sulfate for edible fish has been declared illegal, it significantly destroys the external parasites of fish. When copper sulfate is used to treat valuable fish, the amount of copper can be determined using laboratory diagnostic kits, and then the permissible dose for daily consumption can be determined in this way. Copper sulfate is one of the most widely used substances in tropical fish farms to control the growth and development of phytoplankton and aquatic plants (Havens, 1994). High hardness of the water causes the effectiveness of this drug to decrease, but it is not allowed to use it in water with low hardness (especially less than 50 mg/liter) due to poisoning. One of the most important cases of poisoning of this substance, which is what we usually face is hepatotoxicity and liver poisoning, which in many cases causes liver damage in fish without the fish being killed (Mazandarani *et al.,* 2015).

## 7. The effect of copper nanoparticles on fishs

The current growth of the nanotechnology industry and the increase in the production of engineered nanoparticles due to their special characteristics have caused them to occupy a special place in the world economy. Due to their unique physicochemical properties, nanoparticles can be used in many biological and environmental studies and therefore have attracted the attention of scientists and researchers. In order to meet these needs, the science of toxicology of nanomaterials will play a very important role in the development and expansion of sustainable and safe nanotechnology. The average size of nano particles is in the range of 1 to 100 nm. By changing the size of the particles from micrometer to nanometer, which is equal to $^{9-}10$ or one billionth of a meter, due to the increase in the ratio of the surface to the volume of the particles, all the physical and chemical properties change and the reactivity of the particle increases greatly(Liu, 2006). Copper nanoparticles are used as a biocide in the formulation of biological anti-adhesion paint in the hull of ships and submarines, in docks and also in some fishing tools. Other important applications of these materials are as antimicrobials, insecticides, and sensors (Lei R *et al*., 2008). Due to the fact that with the increase in the growth rate of farmed fish, the duration of keeping and also its costs are reduced, so the main issue in aquaculture is the growth of the farmed species. Among the limiting factors for fish growth, nutritional factors are very important. Some of these factors are related to the rare or essential elements in the diet, which, if they are provided optimally, will create proper growth. Based on the presented studies, organic copper or copper in the form of nanoparticles has more biosupply compared to mineral copper. If the particle size of large copper molecules is reduced to the size of nano particles, small molecules can be easily absorbed from the intestine and as a result the digestibility of copper in the digestive system increases. Reducing the size of the particles increases the reaction surface per unit volume and greatly reduces the effect of barriers to the penetration of particles into the body (Dang *et al*., 2009; Wang *et al.,* 2011). Unlike the antibiotics and chemicals used that cause sensitivity in the patient's water or cause resistance due to mutation in the pathogenic agent, it seems that nanoparticles are stable antimicrobial agents that do not cause resistance in pathogenic agents (Gogoi *et al.,* 2006). Also, by connecting to the membrane of microorganisms, it prolongs the phase of the growth cycle and the germination time of microorganisms becomes longer (Zhang *et al.*, 2007). One of the reasons that nanoparticles are more effective than other antibiotics is because they have a much greater contact surface with pathogenic microorganisms. Nanoparticles penetrate into the microorganism's membrane by binding to it; They react with proteins containing sulphurous amino acids and phosphorous compounds such as Deoxy Ribonucleic Acid (DNA) and cover the DNA by forming a low weight molecule in the center of the bacteria. Also, studies have shown that the ions of nanoparticles, when they penetrate into the bacterial cell, make the DNA molecules compact and dense, and as a result, destroy its ability to be transcribed (Morones *et al*., 2005). Therefore, if the size of the molecules of mineral elements such as copper reaches the billionth of a meter, copper nanoparticles are actually produced, and with this work, its specific surface area increases significantly. Also, the ratio of external surface atoms to internal atoms increases rapidly with the reduction of particle size, and copper nanoparticles will have a larger external surface and a higher surface activity compared to the usual copper element *(*Hajipour et al, 2012). Because metal oxide nanomaterials have extensive cell-killing activity against bacteria, fungi, and viruses, and copper oxide is one of the most important metal oxides due to its remarkable properties, including antimicrobial properties; Therefore, if Oxidms is attached to nanoparticles, its bactericidal ability increases (Li *et al*., 2011; Wu *et al*., 2012).

## 8. Conclusion

Today, attention to the production and breeding of freshwater species has increased and forecasts have been made, to achieve successful aquaculture, the use of appropriate food rations. In addition to being fully familiar with the needs of different types of aquatic species, fish farming specialists should also be aware of food analysis. Minerals are among the most important components of aquatic diets, which are separated from other nutrients by their main components and inorganic nature, and many of these elements are important due to the existence of structural and metabolic functions in the body of organisms. In addition to the limited access to information on the minerals needed by fish compared to other food groups, there is little information about the mineral requirements of aquatic species compared to land animals, and the reason for this is the absorption of these elements by fish through water and It is food. Copper element is considered as an essential mineral in the nutrition of aquatic animals, and the dependence of the physiological reactions of aquatic growth on the activity of copper-containing enzymes necessitates the continuous need for copper in the diet. It seems that the presence

of copper element is necessary for the formation of melanin pigment and skin pigments, the formation of bones and connective tissue, and excessive amount of copper in aquatic feed can have negative effects on intestinal morphology and increase the rate of apoptosis and cell division in intestinal cells according to the presented studies, organic copper or copper in the form of nanoparticles has more biosupply compared to mineral copper and if the particle size of large copper molecules is reduced to the size of nano particles, small molecules can be easily absorbed from the intestine and as a result copper is digestible. It increases in the digestive system.

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# Design and Development of an Android-Based Flower Classification Application Using Artificial Neural Networks with Backpropagation Method

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**Abstract**
This study investigates the use of artificial neural networks (ANN) employing the backpropagation method to identify flower types based on petal shapes. Android devices were utilized to capture flower images and transmit them directly to a server. Once a sufficient number of images were gathered, the training of the artificial neural network commenced. The flower images were processed to extract shape features using Sobel edge detection followed by thresholding. Subsequently, the data were normalized and fed into the ANN for training. Once the training was complete, the Android devices were capable of capturing new flower images and using the ANN to identify them. The findings of this research indicate that by using a single hidden layer with 35 hidden nodes, the system achieved a flower detection accuracy of 80%.

**Keywords:** ANN, Backpropagation, Flower Classification

## 1. Introduction

Flowering plants, also known as angiosperms, are estimated to have over 200,000 different species (Shrestha et al., 2018). Botanists and plant experts can identify these plants based on their flowers, owing to their extensive training and familiarity with floral characteristics. However, for the average individual without specialized knowledge in botany, recognizing and distinguishing between different flower species can be challenging. Most people are familiar with only a few common types of flowers. To identify a specific flower species, one often has to consult a floral encyclopedia or search online using relevant keywords. Such methods can be cumbersome, especially if one frequently encounters unfamiliar flowers.

Today almost 3.6 billion users (around 45% of the world population and 67% of total mobile phone users) among 5.26 (around 67% of the world population) billion unique mobile phone users of 10.4 billion mobile connections all over the world use smartphone devices (Aznan et al., 2017). People carry their smartphones wherever they go, to the extent that these devices have become integral to their daily lives. Given the widespread

use of smartphones, they present a convenient platform for flower identification. Imagine if simply taking a photograph of a flower with a smartphone could identify its species; it would significantly simplify and expedite the identification process. Android, as a mobile operating system, dominates the current market share (Jaiswal, 2018).

This study draws inspiration from previous research, notably (Hiary et al., 2018), in this study, the authors propose a novel two-step deep learning classifier to distinguish flowers of a wide range of species. First, the flower region is automatically segmented to allow localisation of the minimum bounding box around it. The proposed flower segmentation approach is modelled as a binary classifier in a fully convolutional network framework. Second, they build a robust convolutional neural network classifier to distinguish the different flower types. (Kuznetsova et al., 2020)(Rao et al., 2021), in this paper, present the Global Filter Network (GFNet), a conceptually simple yet computationally efficient architecture, that learns long-term spatial dependencies in the frequency domain with log-linear complexity. The architecture replaces the self-attention layer in vision transformers with three key operations: a 2D discrete Fourier transform, an element-wise multiplication between frequency-domain features and learnable global filters, and a 2D inverse Fourier transform. We exhibit favorable accuracy/complexity trade-offs of our models on both ImageNet and downstream tasks This current research differentiates itself by leveraging edge detection for feature extraction and utilizing Android-based smartphones for both image capturing and direct processing. In another study conducted by Bowo, the template matching method was employed to differentiate input images from database templates. This process involved feature extraction via edge detection followed by image thinning.

Given these advancements and the potential of smartphones, our research aims to build a user-friendly and efficient flower classification application based on neural networks, focusing on harnessing the Android platform for real-time processing.

## 2. Related Theory

### *2.1. Edge Detection*

Edge Detection serves as a pivotal technique in image processing, aiming to identify the boundaries within an image (Marmanis et al., 2018). At the core of this approach lies the principle of detecting significant intensity shifts between adjacent regions. An edge can be conceptually defined as "a connected set of pixels that mark the boundary between two distinct regions" (Waldner & Diakogiannis, 2020). This demarcation often holds essential information about the object, encapsulating its shape and size, making edge detection invaluable in various applications.

The core idea behind edge detection revolves around the examination of pixel intensity changes. When an image is processed, areas where pixel intensity changes abruptly indicate potential edges. These changes can be mapped and identified, producing a simplified version of the image that highlights these critical boundaries.
Edge detectors primarily leverage two types of detectors: row detectors (Hy) and column detectors (Hx). Several operators fall into these categories, with prominent examples being the Roberts, Prewitt, Sobel, and Frei-Chen operators (Meester & Baslamisli, 2022). These operators use mathematical functions to compute the gradient magnitude at each point in the input image, thus providing a measurement of the edge strength.

### *2.2. Artifial Neural Networks*

Artificial neural networks (ANN) are computer models that draw inspiration from the brain's neural architecture (Nwadiugwu, 2020)(Kusnadi et al., 2022). They seek to imitate the brain's capacity for pattern recognition and data-driven learning. ANNs' capacity to adapt to and learn from the data they are trained on has led to their use in a wide range of fields, including image identification, natural language processing, financial forecasting, and more.

Basic Elements:

- Neuron: The basic unit of ANN that receives inputs and produces outputs.
- Weights: Values that determine the strength of the connection between neurons.
- Bias: A constant value added to the result of multiplying input with weights.
- Activation Function: A function that transforms the linear combination of weights, inputs, and bias into the neuron's output.

There are several commonly used ANN architectures:

- Feedforward Neural Network: A network where information only moves forward, from input to output.
- Recurrent Neural Network (RNN): A network where information can move backward, allowing memory of previous inputs.
- Convolutional Neural Network (CNN): Specifically for data with spatial structures, like images.

ANN is a powerful tool in the field of machine learning and artificial intelligence. Despite its drawbacks, with proper understanding and application, ANN can be used to solve various complex problems in various fields.

## 3. Method

The design and development of the proposed artificial neural network (ANN) for recognizing flower types involve distinct stages of training and recognition (Kusnadi et al., 2023). These are elucidated as follows:

1. Training Phase
   The foundation of the training phase rests on the Backpropagation algorithm. The principal objective is to adjust the weights to obtain an optimal neural network configuration. Post-training, the ANN's configuration, including its weights, will be stored in a dedicated file. The weights are adjusted dynamically based on predefined learning rates and momentum rates until the network achieves the desired recognition accuracy for the input data.

2. Recognition Phase
   This phase exclusively focuses on the forward propagation process. The stored ANN configuration file is retrieved, utilizing the weights for data recognition.
3. Image Pre-processing
   Input images undergo initial processing, beginning with edge detection employing the Sobel operator.
   Subsequent resizing accentuates the image clarity through thresholding techniques.
   Every pixel undergoes transformation into a double sequence, ranging between [0,1], derived from the average R, G, B values of each pixel.
4. Data Representation
   The output count of the ANN is automatically determined by the number of flower types present in the database.
   Database indices are converted to binary format, forming the target output sequence.
5. Architectural Details
   The ANN is structured across three layers, as illustrated in Figure 1. The input layer is optimized for images of resolution 150x150 pixels, translating to 22,500 required inputs. A single hidden layer is introduced, the neuron count of which will be ascertained post-identification of the optimal network architecture. The link between the input and hidden layers will be enhanced using the Nguyen and Widrow (1990) optimization method. To expedite the training process, momentum - the additional weight from the subsequent weight change - is employed. Initial base weights will be randomly set within the range [-0.5, 0.5]. Output count will be automatically generated during training based on available data.

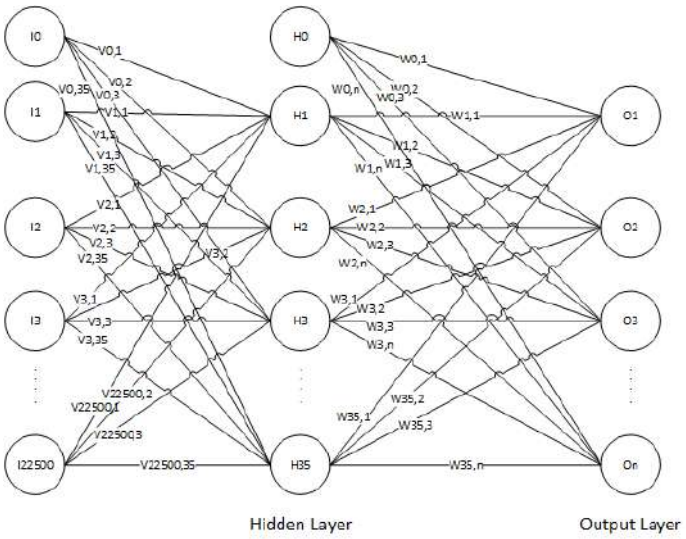


Figure. 1. ANN Architecture

6. Data Distribution
   A 2:1 ratio is maintained between training and testing data. Specifically, the dataset comprises 61 training images and 30 testing images.

## 4. Implementation

During the trial phase, there were 91 images consisting of five types of flowers. Specifically, there were 16 images of Pink Roses, 19 of Frangipani, 16 of Purple Trumpet flowers, 22 of Plumeria, and 18 of Red Roses. From each flower type, six images were selected as testing data. This resulted in 30 images used for testing and 61 for training.

The initial weights used in the experiment were randomized for every trial. This decision was based on previous tests which showed that artificial neural networks with randomized initial weights had better accuracy than those with static initial weights. The training parameters for the neural network were set as follows: a learning rate of 0.001, a momentum rate of 0.01, and a threshold of 0.451. The choice of a 0.001 learning rate was due to the fact that a smaller learning rate increases the chances of the neural network's weights achieving maximum accuracy. However, a drawback of a smaller learning rate is that it takes a longer time to train the neural network. The momentum rate was set at 0.01 for the same reasoning behind the learning rate choice. The threshold of 0.451 was chosen because the initial experiment set a starting threshold close to 0.5.

After three days of training, the data from the experiment revealed that a hidden node count of 35 was optimal. This was because the accuracy obtained from the experiment was 80%, and it was the highest accuracy achieved among smaller hidden nodes.

## 5. Discussion

The advancement in machine learning, especially in neural networks, has enabled a myriad of applications across diverse domains. The development of an Android-based flower classification application, as discussed, is a testament to this. A few key aspects from the given results deserve attention:

- Data Division: The experiment leveraged 91 images from five distinct flower types. The choice of selecting only six images from each type as testing data, thereby using the majority (61 images) for training, underscores the importance of having a robust training dataset to train the neural model comprehensively.
- Randomized Initial Weights: Traditionally, neural networks can be sensitive to the initial choice of weights. The decision to employ randomized weights every trial, and its resultant improved accuracy over static initial weights, could be attributed to the network's capability to escape local minima and explore the solution space more efficiently. This approach, although not universally optimal for every problem, seems

to have been very effective for this specific flower classification task.

- Learning Rate and Momentum: The choice of a smaller learning rate, 0.001, aligns with the idea that smaller steps can lead the network towards a more precise solution. However, as highlighted, it comes with the trade-off of longer training times. The addition of momentum, set at 0.01, helps accelerate the network's convergence by adding a fraction of the previous weight update to the current one. This ensures a smoother and possibly faster approach to the solution, especially in valleys in the loss landscape.
- Threshold Setting: The chosen threshold value of 0.451, close to 0.5, is intriguing. While the reason behind this specific threshold isn't detailed, it would be interesting to explore how variations in this value might impact the network's performance.
- Optimal Hidden Node Count: After the rigorous training process, determining that 35 hidden nodes yielded the highest accuracy is noteworthy. While the model achieved an impressive 80% accuracy, one might wonder if further fine-tuning or augmenting the training data could lead to even better results.
- Practical Implications: The application, once deployed on Android devices, could serve botanists, flower enthusiasts, or even common users in recognizing and classifying flowers. The real-world effectiveness of the app would be contingent upon its performance with diverse and unseen data, beyond the 91 images used during development.
- Future Enhancements: It would be worthwhile to consider augmenting the dataset with more images, both in terms of quantity and variety. Incorporating images taken under different conditions—like varying lighting, angles, or seasons—might make the model more robust. Also, exploring deeper architectures or other advanced neural network techniques could further improve accuracy.

## 4. Conclusion

From the research conducted, it can be concluded that the flower identification application using the artificial neural network with the backpropagation method and edge detection on Android has been developed using a server-client system. This application can recognize flowers that have been trained with an accuracy rate of 80%. This level of accuracy is likely influenced by the limited dataset and the potential for significant variations in patterns from images of similar flowers. To further expand on the findings:

- Server-Client System: The decision to employ a server-client system for the application suggests a centralized model where the computational-intensive process of neural network predictions can be handled by the server, thus alleviating the client (or user's Android device) from the heavy processing. This design choice might enhance the application's scalability and performance on diverse Android devices (Gupta et al., 2023).
- Accuracy Rate: An accuracy of 80% is commendable, especially given the inherent challenges in flower pattern recognition due to the intricacies and nuances in flower designs. However, for practical, real-world applications, a higher accuracy would be desirable.
- Dataset Limitations: The limited dataset is a constraint that might have impacted the model's performance. A more extensive dataset that encompasses a wide variety of flower images, captured under different conditions and from various angles, could potentially enhance the model's accuracy and robustness.
- Pattern Variations: The observation that there are significant variations in patterns even among images of similar flowers underscores the complexity of the task. It suggests the need for a more robust preprocessing or feature extraction method, which could aid the neural network in discerning and distinguishing between nuanced patterns more effectively.
- In light of these findings, future work could focus on dataset augmentation, refining the feature extraction process, and perhaps exploring more sophisticated neural network architectures or hybrid models to further improve the application's accuracy and reliability.

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# Computational Investigation on Flow and Power Output of Solar Chimney Power Plants by Changing Collector Entrance Geometry

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**Abstract**
The use of fossil fuels for generating power has leaded to the reduction of fossil fuel resources and many adverse influences involving climate change and environmental pollution. Solar energy has a potential to provide eco-friendly energy with a great energy supply for producing heat and electricity. Basic parts of the system are the collector, chimney and turbine. The collector is a vital component of the system and its geometrical features noticeably influence the power plant efficiency. In the current work, a three dimensional computational fluid dynamics (CFD) simulation of a SCPP based on the Manzanares prototype is performed to scrutinize the impact of collector entrance height ($H_e$) ranging from 0.75 m to 2 m on the solar chimney power output. Computational model is developed by employing RNG k-ε turbulence and discrete ordinates (DO) coupled with solar ray tracing models through ANSYS Fluent software. The model is validated using measured data published in the literature. The numerical results reveal that reducing He improves maximum velocity ($V_{max}$), power output and pressure difference in the turbine at the expense of decreasing air mass flow rate. The highest velocity of 19.45 m/s is achieved with $H_e$ = 0.75 m and $V_{max}$ enhances by 36.20% compared to base model with $H_e$ = 1.85 m at 1000 W/m$^2$. Besides this configuration provides the maximum power output of 66.51 kW and augments power output to 31.74% compared to the base case at 1000 W/m$^2$.

**Keywords:** Solar Chimney, CFD, Collector Entrance Height, Maximum Velocity, Pressure Drop, Power Output

## 1. Introduction

Renewable energy is energy generated from abundant and continuously replenished natural resources including solar, wind, hydro, tidal, geothermal, biomass and wastes. It is a key to reduce the dependence on fossil fuels and thus to have a safer, cleaner, and sustainable world (Peake, 2018). Solar energy has a potentially critical role in

providing eco-friendly energy for generating electricity and heat (Tyagi et al., 2020). The solar chimney system is capable of producing the electric power from the solar energy with no greenhouse gases emission, especially in rural areas where solar chimney power plant (SCPP) technology offers freely available energy resources to augment access to electrical energy (Okoye & Taylan, 2017). SCPP is established on three technologies (the greenhouse, chimney and wind turbine) joined together to harness energy from the sun (Kasaeian et al., 2017).
Major components of a solar chimney are chimney, collector and turbine. The collector whose roof made up of a semi-transparent material (plastic or glass) received the solar radiation into the system and then transmitted to the ground which leads to a rise in temperature here. Namely, the greenhouse effect is generated by the semi-transparent collector surface through which the short wavelengths of visible light from the sun pass but the longer wavelengths of the solar radiation are unable to pass. This elevates the ground temperature under the collector. Thus, the heat transfer takes places between the heated ground surface and fresh air coming from the collector entrance. Temperature difference on the ground results in density gradient which produces a buoyancy force. Therefore the heated system air moves upwards and it is directed towards the outlet of the chimney. With a long tubular geometry, the chimney generates a pressure difference and augments the velocity of the system air. SCPP uses the buoyancy-induced convective flow which rotates the turbine installed close to the inlet of the chimney. The turbine converts the air kinetic energy to the rotational energy and eventually into electricity in a generator (Pradhan et al., 2021).

Heat is stored in the natural soil but an additional absorber (energy storage) layer under the roof is needed to meet the requirement of SCPP system working during the night or cloudy days (Guoa et al., 2019). The absorber stores the thermal energy transferred by the collector and employs it to heat air during the absence of sun providing electricity production for 24 hours. The selection of a suitable absorber material is crucial to improve operational performance of the SCPP system. Aluminium, canvas, black and clear visqueen are used as absorber plate materials (Das & Parvathy, 2022). Besides, thermal storage capacity of SCPP is improved by introducing water filled black tubes laid on the ground to store heat during day. At night-time, the water in the tubes emits the heat while the air inside the collector beginning to cool (Zhou et al., 2010).

Geometrical parameters of solar chimney components such as collector and chimney influence performance of SCPP systems (Cuce et al., 2022). Main geometric features of the system are the collector height, radius and slope and the chimney diameter and height. Besides divergent and convergent collector and chimney design impacts the efficiency of SCPP system.

Researchers recently examined different collector geometries to enhance performance of SCPP systems. Hassan et al. (2018) accomplished computational research on changing the slope of the collector (4°-10°) and chimney divergent angle (1°-3°) with fixed other geometric parameters to intensify the system performance employing ANSY Fluent CFD codes. They pointed out that the chimney having 1° divergent angle leaded to remarkable increment in maximum airflow velocity and power output at smaller chimney height. Golzardi et al. (2021) conducted the experimental tests and a three dimensional (3D) CFD analysis to scrutinize the influences of collector entrance of square and circular collectors on airflow velocity and heat transfer characteristics inside the chimney. They observed that reducing collector entrance of square collector by one-half and that of circular collector by one-quarter augmented outlet velocity and thermal efficiency of the chimney. Cuce (2022) introduced a 3D model based on Manzanares pilot plant to explore the effect of the dimensionless parameter called collector radius rate (collector radius/ the pilot plant collector radius) on power output for the 90° model by ANSYS Fluent. Their results displayed that a rise in the collector radius rate enhanced power generated by the plant but at a certain collector size (upto one and a half times the collector radius) and then the efficiency diminished due to the high cost and an increase in the space occupied by the collector.

According to the available literature review, the collector geometric characteristics significantly influence air flow and power production in the system. In the current work, new collector geometries are developed by varying the height of the collector entrance ($H_e$) from 0.75 m to 2 m for fixed collector length and chimney geometric parameters. The distance between the ground level and chimney inlet is also kept constant. Since the region between chimney inlet and collector outlet is altered by changing He for each configuration, the introduced solar chimney geometries in this work are different from previous CFD investigations [Cuce et al., 2022a; Hassan et al., 2018; Golzardi et al., 2021; Cuce, 2022; Sen et al., 2021). The impacts of new produced

configurations on the solar chimney performance characteristics are analyzed and discussed by considering material and environmental features of the Manzanares pilot facility using ANSYS Fluent.

## 2. Materials and methods

In the present work, governing equations (continuity, momentum and energy) combined with the discrete ordinates (DO) radiation and turbulence models are solved in a coupled manner via ANSYS Fluent. Discrete ordinate (DO) radiation model is employed to stimulate solar rays passing through the semi-transparent (glass) collector. Ray tracing option in solar load model is selected to include impacts of incident solar radiation from the sun's rays in the calculation. Assume that the flow in the SCPP system is turbulent, incompressible, 3D and steady-state. Since the RNG k-ε turbulence model simulates the flow within the system well (Hassan et al., 2018; Cuce, 2022; Sen et al., 2021; Hachicha et al., 2023), this model is utilized in this study. The kinetic energy (k) and dissipation rate (ε) equations in the model are (ANSYS Fluent, 2018):

$$\frac{\partial}{\partial x_i}\left(k\rho u_i\right)+\frac{\partial}{\partial t}\left(k\rho\right)=\frac{\partial}{\partial x_j}\left(\mu_{eff}\alpha_k\frac{\partial k}{\partial x_j}\right)+G_k+G_b-\rho\varepsilon-Y_M+S_k \quad (1)$$

$$\frac{\partial}{\partial x_i}\left(\varepsilon\rho u_i\right)+\frac{\partial}{\partial t}\left(\varepsilon\rho\right)=\frac{\partial}{\partial x_j}\left(\mu_{eff}\alpha_\varepsilon\frac{\partial \varepsilon}{\partial x_j}\right)+C_{1\varepsilon}\frac{\varepsilon}{k}\left(C_{3\varepsilon}G_b+G_k\right)-C_{2\varepsilon}\rho\frac{\varepsilon^2}{k}-R_\varepsilon+S_\varepsilon \quad (2)$$

The Boussinesq approximation is applied to determine air density change in the system as appropriate for modeling the buoyancy flow.

$$\left(\rho-\rho_a\right)g\approx-\rho_a\beta\left(T-T_a\right) \quad (3)$$

where $\rho_a$ and $T_a$ are air density and temperature. β and g present the thermal expansion coefficient and gravitational acceleration.
Power output, $P_o$ of the SCPP system is determined by:

$$P_o=\eta_t Q_v\Delta P_t \quad (4)$$

where $\eta_t$ is the efficiency of turbine which is generally taken to be 0.8 (Abdelmohimen & Algarni, 2018; Cuce et al., 2020; Mebarki et al., 2022). $Q_v$ is the volume flow rate of air. $\Delta P_t$ is pressure drop in the turbine. It is determined by calculating the average pressure difference ($P_t$) at the turbine considered to be located 9 m above ground level using the CFD simulation (Cuce et al., 2020).

$$\Delta P_t=r_t P_t \quad (5)$$

where $r_t$ is the turbine pressure drop ratio and $r_t = 2/3$ (Mebarki et al., 2022).
The 3D geometric model is built in the ANSYS DesignModeler. The geometric features of the developed model are determined with reference to the Manzanares solar chimney constructed dimensions in Table 1 (Haaf et al., 1983).

Table 1: Model dimensions based on the Spanish prototype

| Geometric characteristics | Value |
|---|---|
| The radius and height of the collector | 122 m - 1.85 m |
| The radius and height of the chimney | 5.08 m - 194.6 m |
| The thickness of the ground | 0.5 m |

The thicknesses of chimney and collector are 0.00125 m and 0.004 m. As illustrated in Figure 1(a), instead of simulating the full geometry, 15° CFD model of Manzanares prototype is improved to reduce the computational

time. The model geometry is meshed with an unstructured tetrahedral grid using ANSYS Meshing as demonstrated in Figure 1(b).

The boundary conditions adapted to CFD model are illustrated in Fig. 1(a). Pressure inlet and outlet boundary conditions are applied at the collector inlet and the chimney outlet respectively. The atmospheric pressure is specified at the inlet and outlet. Wall boundary conditions are assigned to surfaces of the ground, collector and chimney as demonstrated in Figure 1(a). The opaque and adiabatic wall boundary conditions are defined at the ground and chimney walls, respectively. Convection thermal boundary condition is employed for the collector and heat transfer coefficient is fixed to 10 $W/m^2K$ [20]. The collector is considered as semi-transparent. Ambient air temperature and density is 293.15 K and 1.2046 $kg/m^3$. To reduce computational domain, symmetry boundary condition is applied on two symmetric planes as shown in Figure 1(a).

In order to setup CFD simulation, the component's thermophysical properties in Table 2 are defined in ANSYS Fluent. The equations are discretized using the finite volume approach. SIMPLE scheme is used for pressure-velocity coupling. The pressure is interpolated using a PRESTO method while momentum, turbulence and energy terms were spatially discretized using the second-order upwind scheme.

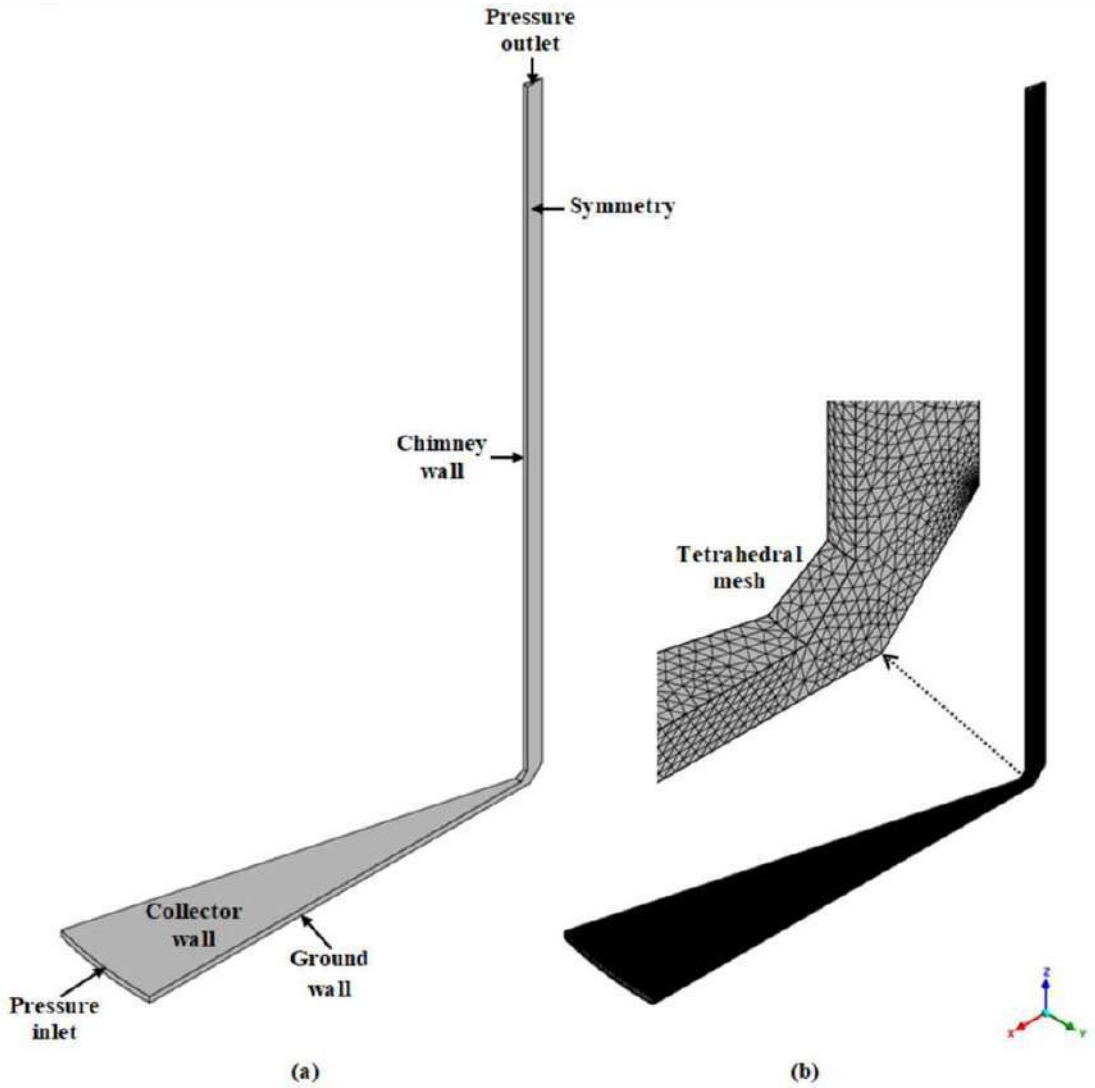


Figure 1: (a) Computational model and boundary conditions, (b) grid structure of the model

Table 2: Thermophysical features of the components employed in CFD simulation

| Properties | Chimney | Collector | Ground |
|---|---|---|---|
| Thermal conductivity (W/mK) | 202.4 | 1.15 | 1.83 |
| Density (kg/m$^3$) | 2719 | 2500 | 2160 |
| Specific heat (J/kgK) | 871 | 750 | 710 |

## 3. Results and discussions

In the current study, the impact of distinct collector entrance configurations on fluid flow and performance characteristics is analyzed employing ANSYS Fluent based on finite volume method. Prior to carrying out CFD simulation, the grid-independent study is conducted for three different mesh sizes. $V_{max}$ values of three grid configurations are demonstrated in Table 3. For mesh number of 386041, percentage variation in $V_{max}$ is examined to be 0.92 at 1000 W/m$^2$. Comparison of similar studies from literature indicates that this variation is well suited for the simulation and thus this element size is chosen for the rest of the research.

Table 3: The results of grid independent test for CFD model

| Number of cell | $V_{max}$ (m/s) | % change in $V_{max}$ |
|---|---|---|
| 192746 | 13.63 | - |
| 268921 | 14.15 | 3.82 |
| 348018 | 14.28 | 0.92 |

The model is verified with the measured data of the Manzanares's chimney (Rabehi et al., 2017) and compared with previous numerical studies in Figure 2.

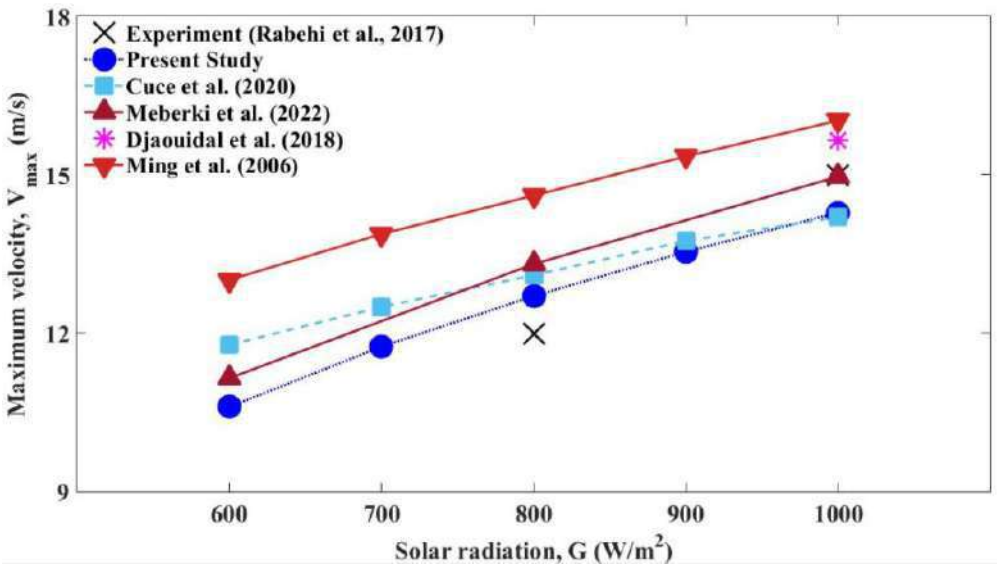


Figure 2: Comparison of maximum velocity values of the base CFD model with calculated and measured data available in literature

In comparison to results from previous studies, computed maximum velocity values are in good agreement with the measured values at 800 and 1000 W/m$^2$. Besides, it is consistent with Cuce et al.'s (2020) and Meberki et al.'s (2022) numerical studies at 600-1000 W/m$^2$.

Figure 3 demonstrates the variation of $V_{max}$ as a function of $H_e$ ranging 0.75 m to 2 m at 800 and 1000 W/m$^2$.

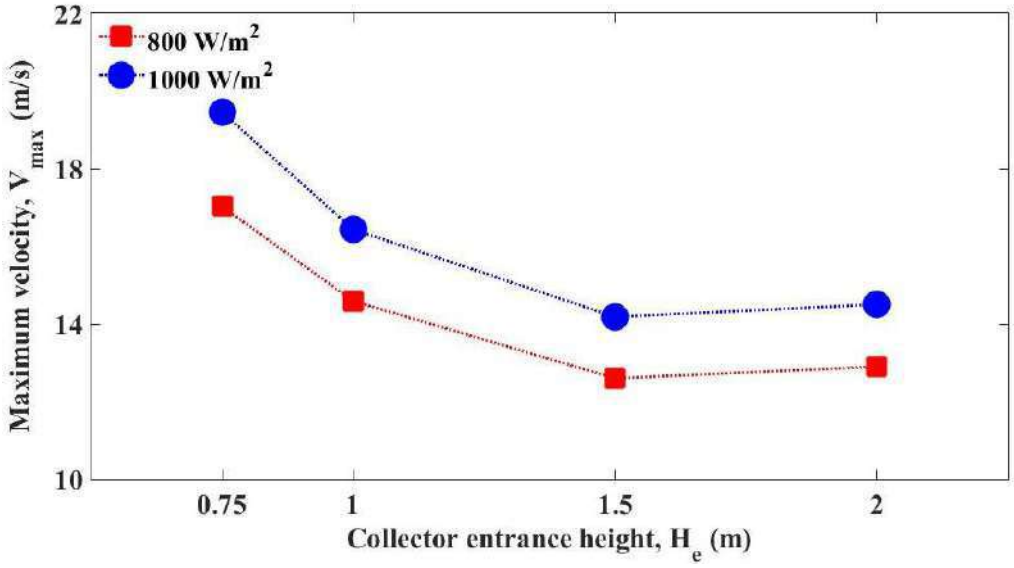


Figure 3: Variation of maximum velocity with collector entrance height

It is obvious from Figure 3 that there is a nonlinear relationship between $V_{max}$ and $H_e$. A slight decrease in Vmax is observed from $H_e$ = 2 m till $H_e$ = 1.5 m and then $V_{max}$ is significantly enhanced with decreasing $H_e$. The highest air velocity of 19.45 m/s is obtained for $H_e$ = 0.75 m compared the base model having $V_{max}$ = 14.28 m/s at 1000 W/m$^2$. The reason behind this sharp increase is that the collector inlet area is reduced significantly with $H_e$ = 0.75 m and this leads to notable enhancement in air velocity of the system.

In Figure 4, the regions near the turbine located and collector outlet are examined in detail to understand the impact of $H_e$ on the distribution of air velocity at 1000 W/m$^2$.

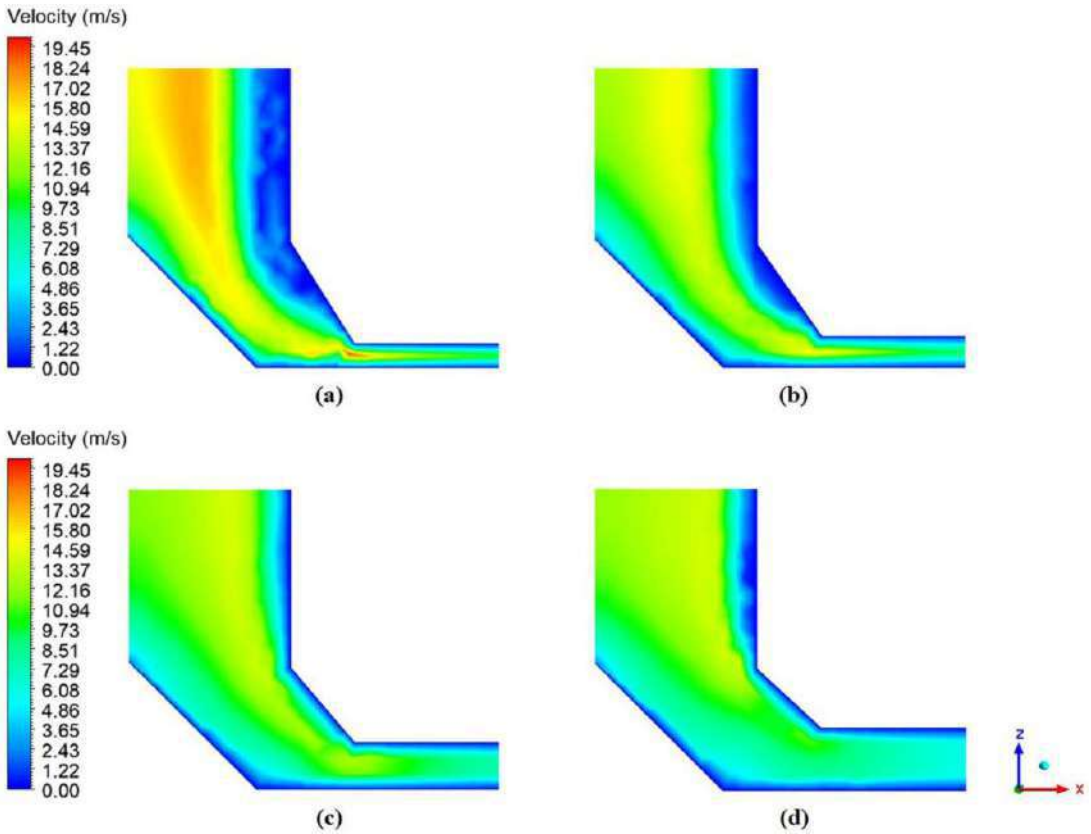


Figure 4: Air velocity distribution near the turbine installed and collector outlet for (a) $H_e$ = 0.75 m, (b) $H_e$ = 1 m, (c) $H_e$ = 1.5 m and (d) $H_e$ = 2 m at 1000 W/m$^2$

As illustrated in Figure 4, the area between the chimney inlet and collector outlet is varied with reducing He owing to the distance between the ground and chimney entrance remaining same. This leads to the enhancement of velocity distribution around the collector outlet and chimney inlet. Although maximum air velocity is diminished slightly for reducing $H_e$ from 2 m to 1.5 m in Figure 3, the local air velocity around the collector outlet is augmented significantly with this configuration in Figure 4 (c). It is confirmed the aforesaid result that the configuration with $H_e$ = 0.75 m intensifies air velocity remarkably in the region where turbine placed. It is important owing to the increased kinetic energy of the system improving electricity production from the chimney.

Air mass flow rate ($\dot{m}$) and pressure drop around turbine are two important parameters that impact the solar chimney efficiency. That is, $P_o$ is strongly dependent the air volume flow rate and pressure difference across the turbine as seen in Equation 4.

Figure 5 demonstrates the variation of $\dot{m}$ as a function of $H_e$ ranging 0.75 m to 2 m at 800 and 1000 W/m$^2$. As illustrated in Figure 5, a decreasing trend of $\dot{m}$ is observed with a decrease in $H_e$. It is expected that $\dot{m}$ values for $H_e$ = 0.75 and 1 m should be elevated because of these configurations notably enhancing $V_{max}$ in Figure 3. But the collector entrance area is decreased with reducing $H_e$ and this causes lower air mass flow rate within the chimney. $\dot{m}$ is 728 kg/s for $H_e$ = 0.75 m compared to the base case with $\dot{m}$ = 1062 kg/s.

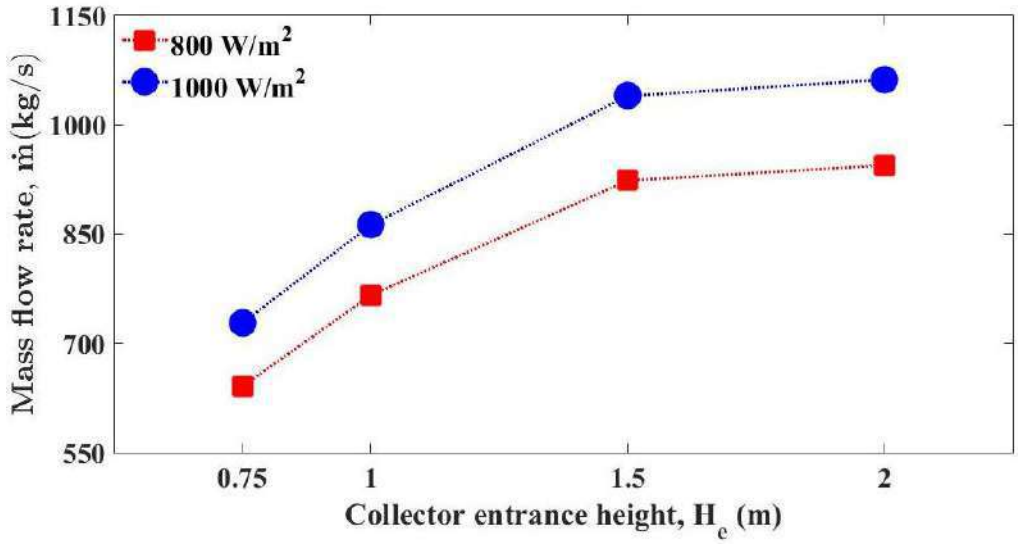


Figure 5: Variation of mass flow rate with collector entrance height

Figure 6 shows the change of pressure difference in a turbine as a function of $H_e$ ranging 0.75 m to 2 m at 800 and 1000 W/m$^2$. As seen in Figure 6, the lower collector entrance results in a larger pressure drop through the turbine. The highest pressure drop of 206.3 Pa is achieved for He = 0.75 m at 100 W/m$^2$.

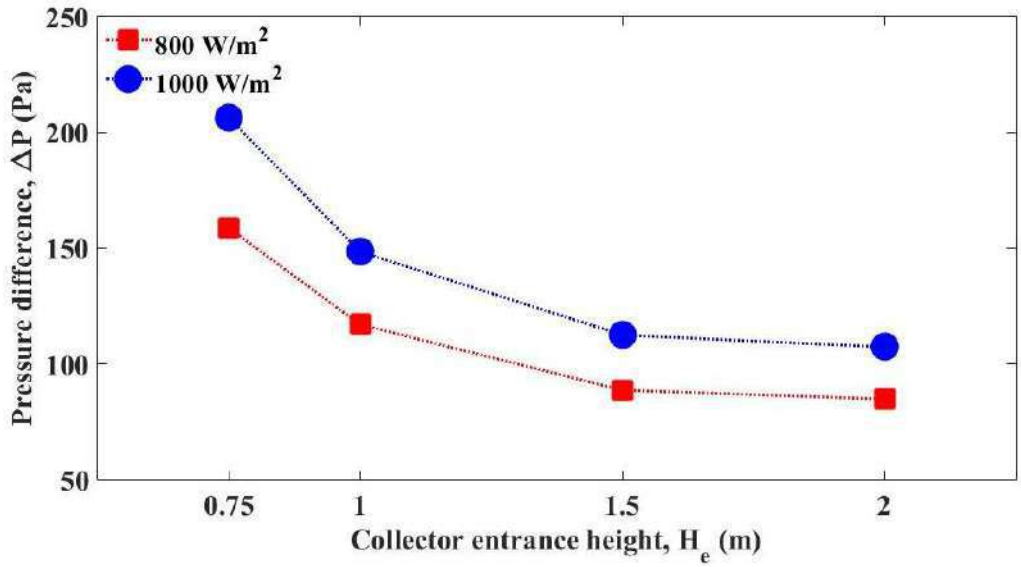


Figure 6: Variation of pressure drop in a turbine with collector entrance height

Figure 7 demonstrates the change of $P_o$ of the SCPP system as a function of $H_e$ ranging 0.75 m to 2 m at 800 and 1000 W/m$^2$. As shown in Figure 7, a reduction in $H_e$ yields to enhancement in $P_o$ of the system at both 800 and 1000 W/m$^2$.

It is noticed that pressure difference where the turbine placed plays a dominant role in augmenting $P_o$ of the solar chimney. Namely, the increased pressure drop with narrow collector entrance in Figure 6 leads to a significantly rise in $P_o$ of the chimney, especially at 1000 W/m2. It is concluded that decreasing air mass flow rate with a lower collector entrance is compensated by higher pressure drop gained near the turbine. Therefore for $H_e$ = 0.75, the maximum $P_o$ of 66.51 kW is achieved and this configuration improves $P_o$ to 31.74% in comparison to the base model at 1000 W/m$^2$.

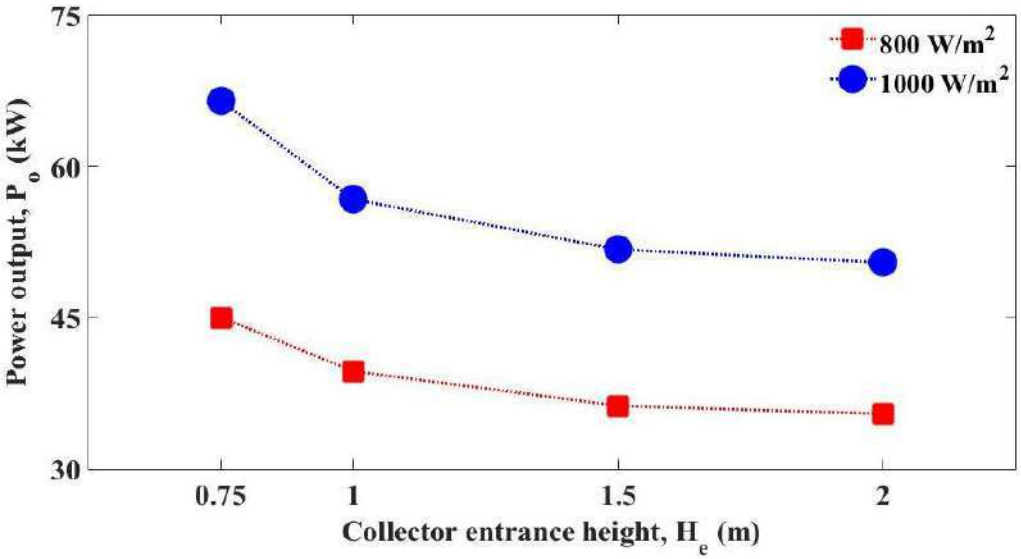


Figure 7: Variation of power output of the system with collector entrance height

## 4. Conclusions

This paper examines numerically the impact of the entrance height of the collector on enhancement of power production in a solar chimney system by constructing a 3D model employing ANSYS Fluent CFD code based upon the finite volume discretization. The collector height is changed from 0.75 m to 2 m by other dimensions of the components and the distance between the ground and chimney entrance of the model keeping unchanged.

After grid independent test and verification of the model, performance characteristics are evaluated as a function of $H_e$. The main findings are summarized as follows:

- The predicted $V_{max}$ values obtained with the present CFD model agree well with measured data compared to the results of the former numerical studies at 800 and 1000 W/m$^2$.
- He is an influential geometric parameter that affects $P_o$ of the system.
- New proposed configurations obtained by altering collector entrance with a constant distance between the ground and chimney inlet is more efficient to improve $P_o$ of the plant for $H_e$ = 0.75 and 1 m.
- Reducing air mass flow rate with decreasing He is met with higher pressure drop gained close to the turbine.
- The configuration with $H_e$ = 0.75 m provides the highest $P_o$ of 66.51 kW, $V_{max}$ of 19.54 m/s and the maximum pressure drop of 206.3 Pa whereas this configuration reduces air mass flow rate by 31.39% compared to the base case at 1000 W/m$^2$.
- This study which provides key insights for determining appropriate collector entrance geometry to enhance the system's power output will be helpful for further solar chimney numerical analysis and designs.

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**Conflict of Interest**: The authors declare no conflict of interest.

**Informed Consent Statement/Ethics Approval**: Not applicable.

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# The Impact of Health Information Systems on Patient Outcomes

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**Abstract**
The Internet of Medical Things has actualized the digital transformation of the healthcare industry where information systems are leveraged by providers for enhanced performance and improved patient outcomes. In light of these systems' outsized role in healthcare management, it is essential to explore impacts on healthcare by discussing the advantages and disadvantages of Health Information Systems (HIMS). This study investigates the strengths and shortfalls of HIMS. It addresses the gap in scholarly literature that often focuses on isolated effects rather than providing a generalized understanding of HIMS advantages and liabilities. This research used the narrative review methodology that aggregates and synthesizes literature on the subject. The body of the text discusses advantages of health information systems such as enhancing systematic management of health data, reducing medical errors, promoting operational efficiency and decision making. The vulnerabilities of information systems discussed herein are implementation costs and privacy concerns. The terminal summarizes the paper's content, connecting it to impact on patient outcomes.

**Keywords:** Systematic Management, Medical Errors, Operational Efficiency, Decision-Making, Implementation Costs and Privacy

## 1. Introduction

Concepts such as patient-centeredness, value creation, best outcomes, evidence-based practice, and effective communication characterize modern healthcare (Kwame & Petrucka, 2021). Technology has enabled healthcare professionals to communicate effectively, resulting in improved patient care and the achievement of organizational goals. Providers utilizing health information technology can easily share information, monitor compliance, and gauge and enhance their performance (Alolayyan et al., 2020). However, like any other electronic data management system, this technology is plagued by privacy and security issues. However, studies in this field often focus on specific aspects, examining the strengths and limitations of healthcare information technology, while repositories lack diverse scholarly articles that comprehensively analyze the pros and cons of healthcare information systems. Therefore, this paper aims to comprehensively analyze this topic, with a specific focus on patient outcomes. By addressing this research gap, the paper aims to provide valuable insights into the advantages and limitations of healthcare information systems and their impact on patient care.

Automation is the proverbial indicator of the entrenchment of information technology which has transformed all life aspects, including healthcare. Information systems have revolutionized healthcare and transformed patient data management for improved care which reduces the frequency of adverse patient outcomes (Astier et al., 2020; Rudin et al., 2020). These systems have replaced inefficient physical records, ushering in an era of systematic data management that enables easy access to patients' information for a wide range of healthcare operations and research endeavors. Healthcare information tools like electronic health records, databases, and registries, have become invaluable tools offering various benefits such as enhanced operational efficiency, reduced medical errors, improved decision-making, and drive advancements in patient care (Wood et al., 2021). However, there are also challenges and potential drawbacks that need to be considered, as with any technology. Disadvantages of health information systems include implementation costs and privacy concerns. This research paper explores the advantages and downsides of healthcare information systems, delving into how these systems have transformed the healthcare landscape, ultimately enhancing the quality of patient care. Broadly, it is divided into advantages and disadvantages subsections, and a conclusion to capture the gist of the text.

## 2. Purpose Statement

This paper addresses an existing gap in scholarly literature regarding the comprehensive exploration of the advantages and disadvantages of health information systems (HIS). While numerous studies have focused on isolated effects of HIS, there is a lack of in-depth research that systematically examines the transformative impact of HIS on various aspects of healthcare delivery. This paper aims to contribute to the expanding knowledge body by synthesizing representative literature and perspectives on the advantages and disadvantages of HIS. Furthermore, the implications of these findings on patient outcomes will be inferred for valuable insights for healthcare practitioners, administrators, and policymakers.

## 3. Methodology

This study utilizes a qualitative research approach to integrate the effects of health information systems. The methodology was systematic collection and analysis of peer-reviewed articles for insights on these systems' advantages and disadvantages. Only articles published within the last three years were considered. Furthermore, articles had to undergo a rigorous peer-review process and be published in reputable journals. Electronic databases such as PubMed, and Google Scholar were searched using keywords related to health information systems and their effects. Initial searches yielded a large number of articles, which were screened based on titles and abstracts and the irrelevant ones were excluded. Importantly, this study focused on qualitative analysis of peer-reviewed articles without primary data collection or quantitative analysis.

## 4. Literature Review

In an article documenting the evolution of digital health, Cuff (2023) observes that technology has shifted healthcare focus from providers and become patient-centric. It involves stakeholders in diverse areas, such as healthcare, data technologies, and health informatics to improve diagnosis and disease management. Bulgarelli et al. (2020) highlight the potential of databases for secondary analysis of clinical data. By leveraging these repositories, healthcare providers can gain valuable insights into various facets of care for evidence-based practices and improved patient outcomes. Health digitization promotes epidemiological information for disease management. Jonker et al. (2022) suggest data information which assists healthcare providers to effectively manage diseases by identifying trends, tracking outcomes, and informing targeted interventions. Torab-Miandoab et al. (2023) emphasize that interoperability is crucial in maintaining care quality and preventing resource wastage, highlighting the essence of data standardization and seamless communication between healthcare entities. Health information systems can help mitigate errors by providing comprehensive patient records, decision support systems, and alerts, leading to enhanced patient safety and reduced medical errors. Rodziewicz et al. (2022) contend that errors of omission and commission, which can compromise patient safety, can be mitigated through cross-professional collaboration and communication to improve outcomes for all patients.

Küng et al. (2021) conducted a study on the effects of barcode technology on medication preparation and administration systems. Their findings suggest that health information systems utilizing barcode technology can improve medication safety, reduce errors, and streamline workflows, ultimately enhancing patient care. Seixas et al. (2021) emphasize how electronic systems generate data that can inform administrators on resource allocation and help optimize employee performance. Health information systems enable data-driven decision-making, facilitating efficient resource allocation and improving overall healthcare service delivery. Health information systems utilize algorithms and automated clinical knowledge bases to provide evidence-based recommendations to healthcare providers. Winter et al. (2023) highlight how such systems aid in clinical decision-making, resulting in improved patient outcomes. For instance, these systems have been shown to decrease the number of hypoglycemic events, promoting safer and more effective patient care (Kouri et al., 2022).

Research by Bulgarelli et al. (2020) estimates that implementing systems such as electronic health record (EHR) systems is a significant financial burden; in addition to the initial implementation costs, organizations need to manage the necessary back-office technology, including servers, data backup, storage, and other infrastructure (Elharish, 2021). Keshta and Odeh (2020) and Basil et al. (2022) discuss the challenges associated with inappropriate data releases from healthcare organizations and systemic information flows across healthcare-related industries. The HIPAA Journal's Healthcare Data Breach Report highlights the pervasive nature of privacy concerns in the healthcare sector, with a significant number of reported data breaches attributed to external hacking incidents (HIPAA Journal, 2023).

## 5. Literature Gap

The literature gap in this research area lies in the limited availability of scholarly-grade literature that comprehensively explores the advantages and disadvantages of health information systems. While the transformative impact of these systems has been extensively researched, the existing literature predominantly focuses on isolated aspects or specific effects, resulting in fragmented knowledge. Moreover, a significant portion of the available literature comprises popular sources such as health blogs or informal publications, which may lack rigorous academic analysis and evidence. This gap highlights the need for an integrative review that critically examines the overall benefits and challenges associated with health information systems. By conducting a comprehensive analysis of the existing literature, this research aims to fill the gap by providing a scholarly-grade text that systematically evaluates the advantages and disadvantages of these systems.

## 6. Discussion

### *6.1 Advantages of Information Management Systems*

#### 6.1.1 Better health data management

The healthcare industry generates and utilizes a vast amount of data with the aim of improving services. Patient records, diagnostic test results, and biomedical research contribute to this data. However, without systematic management, the meaningful utilization of this data becomes unattainable. Sophisticated informatics solutions play a crucial role in the intricate steps of data processing. Centralized storage and retrieval of patient information exemplify the importance of data organization in databases and repositories, ultimately enhancing data accessibility and retrieval. According to Bulgarelli et al. (2020), databases hold great potential for secondary analysis of clinical data, providing insights into various care facets. Patient registries, which collect data about patients with common characteristics such as a specific diagnosis, have emerged as essential data sources for healthcare practices, drug utilization, and clinical outcomes. These registries provide epidemiological information that assists healthcare providers in managing diseases (Jonker et al., 2022). To enable information exchange and optimize health outcomes, interoperability is essential. Interoperability pertains to the sharing of health data between organizations, guided by standards for use. Different information systems and devices must be able to access, exchange, integrate, and cooperatively utilize data within and across organizations. Interoperability ensures information portability and facilitates data access in the required formats. Torab-Miandoab et al. (2023) highlight the negative impact of a lack of interoperability, which diminishes care quality and leads to resource wastage. As the healthcare industry continues to evolve and face new challenges,

interoperability will play a critical role in mediating output and input systems, enabling efficient data access and fostering improved patient care.

### 6.1.2 Reduced Medical Errors

Reducing medical errors and improving patient safety are critical objectives in healthcare. Medical errors can have serious consequences for patient well-being and can result from various factors, including communication issues and inconsistent procedures. Implementing health information tools such as electronic medical records (EMRs) and barcoding systems has shown promise in decreasing hospital medication errors. Rodziewicz et al. (2022) highlight errors of omission and commission as two types of medical errors that can compromise patient safety. Errors of omission involve crucial actions not being taken, while errors of commission occur when incorrect actions are taken. These errors can range from failing to provide necessary assistance to a patient to administering the wrong medication or mislabeling laboratory specimens. To address these issues, health information tools are employed to improve medication safety. Küng et al. (2021) conducted a study on the effects of barcode technology on medication preparation and administration systems. The researchers found a significant decrease in the overall rate of medication preparation errors when barcode technology was implemented. The risk reduction associated with this decline in medication errors was approximately 54.5%. Barcode technology improves medication safety by enhancing traceability in the supply chain and reducing the likelihood of medication errors during preparation and administration. In the context of the COVID-19 pandemic, Lachman and van der Wilden-van Lier (2021) discuss the utility of barcoding systems. They emphasize that barcoding promotes product integrity and reliability, particularly in the case of vaccines.

### 6.1.3 Operational Efficiency

Hospital Information Management Systems are crucial in enhancing healthcare organizations operational efficiency. These software solutions automate administrative and clinical processes, improving patient outcomes and streamlining operations. One area where HIMS significantly improves efficiency is patient registration and appointment scheduling. By electronically capturing patient information, HIMS reduce errors and enhance data accuracy. This streamlined process simplifies patient registration and enables efficient appointment scheduling, resulting in optimal resource utilization and minimized wait times for patients. Paling et al. (2020) highlight the negative impact of long waiting times in emergency departments on patient outcomes, including higher mortality rates. Efficient appointment scheduling facilitated by HIMS can help mitigate these adverse effects. In a study by Pitter et al. (2022) on OnkoNetwork, a Hungarian cancer patient management network, the implementation of HIMS resulted in a 70% reduction in average waiting times for patients. This improvement was achieved by leveraging the system's capabilities to better issue patient call-ups, thereby optimizing patient flow and reducing delays. HIMS enable data-driven decision-making and allow administrators to allocate resources based on department needs, the specialty of healthcare professionals, and their experience. This ensures that resources are allocated effectively and caregivers' skills are fully utilized. Furthermore, HIMS provide data monitoring and analysis capabilities that allow managers to track performance metrics, optimize employee scheduling, and inform strategic decision-making. Seixas et al. (2021) emphasize how electronic systems generate data that can inform administrators on resource allocation and help optimize employee performance. By monitoring data, managers can prioritize scheduling to meet patients' needs, adjust staffing levels based on demand, and ensure that caregivers are assigned tasks that align with their expertise.

### 6.1.4 Better Decision-Making

Health information systems facilitate improved decision-making in healthcare through various mechanisms, including clinical decision support systems (CDSS). These systems utilize algorithms and automated clinical knowledge bases to provide evidence-based recommendations to healthcare providers, aiding in clinical decision-making (Winter et al., 2023). CDSS encompass a range of functions, such as diagnostics, disease management, alarm systems, and prescription support. They can take the form of computerized alerts, order sets, data reports, clinical workflow tools, and documentation templates. One of the primary benefits of CDSS is their ability to enhance patient safety by reducing medication errors. Computerized provider order entry (CPOE) systems with drug safety software help healthcare providers enter and send treatment instructions while

incorporating safeguards to prevent medication errors. Alerts generated by CDSS are among the most commonly used decision support tools. These alerts can remind healthcare providers of important medical events and guide them in adhering to best practices. For example, CDSS can be used to monitor and manage blood glucose levels, automatically prompting nurses to measure glucose according to specific protocols based on patient demographics and historical trends. This approach has been shown to decrease the number of hypoglycemic events (Kouri et al., 2022). CDSS can also support follow-up care by alerting healthcare providers when patients are due for follow-up appointments or when they deviate from management plans. This proactive reminder system helps ensure that patients receive timely and appropriate care.

### *6.2. Disadvantages of Health Information Systems*

#### 6.2.1 Initial implementation costs

The initial implementation costs of health information systems, particularly electronic health records (EHR), can be a significant barrier to adoption for healthcare organizations. Research conducted by Bulgarelli et al. (2020) provides estimates on the costs associated with implementing EHR systems in multi-physician practices. The study suggests that these practices can expect to spend around $162,000 for EHR implementation, with a major portion of the expenses allocated to maintenance costs in the first year. When it comes to implementation, there are two primary deployment options to consider: on-premise and cloud-based. With on-premise deployment, the EHR solution is hosted on the organization's own servers. This may involve purchasing a perpetual license, which typically requires a significant upfront fee. Additionally, organizations need to manage the necessary back-office technology, such as servers, data backup, storage, and other infrastructure (Elharish, 2021). On the other hand, cloud-based deployment involves storing data on the vendor's servers, accessible through the internet. This model typically involves a subscription-based pricing structure, settled either monthly or annually. While cloud-based EHR systems may incur upfront costs in addition to the subscription, they often offer more flexibility and scalability for healthcare organizations. In addition to the direct implementation costs, it is essential to consider indirect costs associated with healthcare information system implementation. These hidden expenses can make up a significant portion of the overall implementation cost. For instance, budgeting for proper EHR training for healthcare providers is crucial. While training may seem costly, inadequate training can lead to productivity losses and potential errors in patient care (Elharish, 2021). Vendors often highlight the initial productivity dip as employees become accustomed to the new software. Healthcare organizations need to carefully assess their budget and plan for both the direct and indirect costs of implementing health information systems. Proper financial planning, considering factors such as deployment options, maintenance costs, training, and productivity impact, will help ensure a successful and sustainable implementation process.

#### 6.2.2 Privacy issues

Privacy concerns are a significant issue when it comes to healthcare information systems. There are two general categories of privacy concerns: inappropriate data releases from healthcare organizations and systemic information flows across healthcare-related industries (Keshta & Odeh, 2020; Basil et al., 2022). Inappropriate data releases can occur when authorized users intentionally or unintentionally access or distribute information contrary to organizational policies. It can also happen when outsiders breach a system. Systemic concerns relate to the disclosure of patient data to malicious parties who may act against a patient's interests. Healthcare information systems involve the flow of data across various systems within an organization, as well as to secondary users such as payers. This makes health data stored by individual organizations vulnerable to security breaches and confidentiality violations. Internal agents, including valid users, may overstep their boundaries by accessing information for unauthorized purposes, such as viewing records of friends or sharing information publicly. External agents, without authorized access, attempt to access and manipulate data or disrupt the system. Healthcare organizations typically have experience countering internal threats but may have limited experience in protecting health information from external attacks. The HIPAA Journal's Healthcare Data Breach Report for the previous year highlights the pervasive nature of privacy concerns in the healthcare sector. In 2022, there were 707 reported data breaches, making it the second-worst year in history for reported breaches. The preceding year, 2021, reached a historical high with 715 breaches. The majority of these breaches were attributed to external hacking incidents (HIPAA Journal, 2023). Such data breaches put patients and healthcare providers at

risk of fraud and identity theft, but the most significant concern is the potential threat to patient safety. Cyber-attacks can lead to system outages that can last for several weeks, severely disrupting patient care. Although fatalities from these incidents are rare, compromised patient data can impact patient outcomes through delays in diagnosis and treatment.

## 7. Limitations

1. Bias in Source Selection: The research is susceptible to bias due to the inclusion and exclusion of sources. It is conceivable that the researcher purposely or inadvertently favored studies aligning with their preconceived notions, resulting in unbalanced conclusions.
2. Lack of Primary Data: Employing a literature review as the research methodology meant there was no primary data collection. Unlike other research methodologies, literature reviews rely on existing studies and secondary data sources, which can limit the researcher's analytical approaches.
3. Incomplete or Biased Information: Additionally, the study may not have covered all relevant sources due to the likely omission of important studies or alternative perspectives, potentially leading to an incomplete understanding of the topic.

## 8. Conclusion

In conclusion, the advent of information systems has revolutionized the healthcare industry by streamlining data management and improving patient care. These systems have replaced laborious and inefficient physical records, enabling easy access to patient information for various healthcare operations and research purposes. Databases and registries serve as valuable resources for researchers, providing insights into disease management and promoting better patient outcomes. Healthcare information systems have also significantly reduced medical errors, which can have detrimental effects on patient outcomes. Tools like electronic medical records and barcodes ensure precision and accuracy in healthcare processes, minimizing the risk of errors in prescription and diagnosis. Operational efficiency is enhanced through the automation of processes in healthcare information systems. Automated scheduling systems reduce patient wait times and optimize resource utilization. Addressing long wait times positively impacts patient outcomes, as highlighted by research findings. Improved decision-making is another advantage of health information systems. Clinical decision support systems provide healthcare providers with suggestions and recommendations based on patient demographics and historical trends. This assists in administering treatments and implementing care routines, ultimately leading to more informed and effective decision-making. However, it is important to acknowledge the disadvantages of information systems. Prohibitive implementation costs pose a challenge for some healthcare organizations, requiring careful budget planning and resource allocation. Privacy and security issues are also significant concerns, as healthcare information systems can be vulnerable to data breaches and unauthorized access. Mitigating these risks requires robust security measures and ongoing monitoring.

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# Evaluation of the Short-Term Summer Internship Program: A Process-Driven Study at OpenZeka

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**Abstract**
This study evaluated the effectiveness of a summer internship program at OpenZeka, an AI company, in Ankara, in 2021. For this study, a process-oriented qualitative research technique was used. To ensure validity, details such as participant and colleague confirmation and flexibility in the research process were given attention. In order to guarantee the dependability of the research, the researcher's location was specified, a conceptual framework was developed, multiple data were gathered from participants in the social setting where the application was implemented, and the methods of analysis utilized were thoroughly explained. After conducting reviews and analysis, we evaluated a summer internship program and discussed the results from different perspectives. Our recommendations section offers various suggestions to interns, implementing companies, and researchers on how to ensure the success of a short-term internship program and how it can be improved.

**Keywords:** OpenZeka, Summer Internship, Process-Driven Study

## 1. Introduction

This section provides general information about the internship period, including concepts such as internships, internship programs, evaluations, program evaluations, and action research. The chapter concludes by discussing the various approaches found in literature on curriculum evaluations and emphasizing the importance of this research.

The OpenZeka Summer Internship Program for 2021 was scheduled in January and February and was later announced on the company's website and social media channels in March. Interested individuals were able to apply by filling out an application form on the company's website, after giving permission for their personal data to be collected. The program received over 200 applications from different universities. Engineers who specialize in their respective fields conducted a preliminary review of the submitted CVs, and all candidates were provided with constructive feedback. Interviews, whether oral, written, face-to-face or video, were conducted with the shortlisted applicants. Eventually, only 14 applicants were selected for the program. It should be noted that two of the selected applicants were unable to participate in the internship scheduled for April, citing various reasons. In May, a group of 12 individuals began the internship program. The length of each

trainee's internship ranged from 20 to 40 days based on their preference and internship rights. The program ran on working days from May 31st to September 14th. Start and end dates for each candidate were determined individually, with the entire program taking 14 weeks to complete as required by the company. Please note that public holidays are not counted towards the duration of the internship program. Any posts related to the internship process on our company's social media channels and website have been approved by our interns in accordance with Annex-1 of Law No. 6698 on the Protection of Personal Data. During the internship, we worked in the physical office of the company and completed occupational health and safety training at the beginning of the program (see Annex_2). The names and signatures on Annex_1 and Annex_2 are kept confidential according to the General Data Protection Regulation. The internship coincided with the global COVID-19 pandemic, so the company took necessary health precautions. We were required to complete daily HES (Hayat Eve Sığar) health checks, and thankfully, there were no COVID-19 cases during the internship.

It is important to examine the frequently used concepts in this research, including internship, intern, evaluation, and program evaluation. Internship, which originates from the French word "stage," has been defined in various ways in literature. There are different definitions of the term "practical learning period". According to Demir & Demir (2014), it can be understood as the period of applying theoretical knowledge into practice. Meanwhile, Alp (2020, p.16) defines it as the time spent by an individual working in a company to enhance their professional knowledge. Izadpanah, Elinç, Abay, & Küçükköseler (2020) explain it as an educational process that aims to increase professional awareness through practical application of the theoretical and applied knowledge learned during students' education. Tan & Umemoto (2021) and Pan, Guan, Wu, Han, Zhu, Fu, & Yu (2018) view it as a student's real-life working experience, while Tan & Umemoto (2021) also describe it as a global platform for training future engineers. The term "intern" refers to an individual who plays a role in the internship process and is impacted by it. They are typically someone who engages in activities to apply their education in a profession or art field and gain practical experience. This definition was provided by Kozak in 2014. An intern is someone who completes an internship according to specific guidelines. Evaluation refers to the process of assessing the program's activities, attributes, and outcomes. It involves gathering information systematically to enhance the program's efficacy and assess whether the objectives have been achieved. This is based on works by Ertürk (1998), Hamblin (1970), Patton (1997), and Eviren (2017). An evaluation process is responsible for testing whether the objectives and target behaviors outlined in the curricula are successfully met, as planned (Yaşar, 2014). Evaluation is defined as the process of making a judgment on the process or results of a situation or program, assessing its significance based on specific criteria, obtaining feedback on its effects, and assigning values accordingly to improve the training (Eviren, 2017). According to Stufflebeam (2000), the main purpose of evaluation is to improve rather than to prove. Therefore, the primary goal of program evaluation is to continuously enhance the program to a better level and ensure its renewal based on changing situations and conditions. The criticisms that emerged from the face-to-face interviews conducted in this research have contributed to improving the program. Evaluation, which involves measuring the results of a training program based on specific criteria to determine its effects and benefits, is necessary to identify and correct any deficiencies or defects in the program (Eviren, 2017, p. 58).

Different types of program evaluation have been discussed in the literature, with curriculum evaluation typically falling under three categories: diagnostic, formative, and summative evaluation (Demirel, 2007; pp.177-178). During the internship program, interim measurement and monitoring were conducted to identify needs, and the program was evaluated as a whole. Hence, this study employed all three methods of evaluation. Additionally, various models and approaches to curriculum evaluation have been suggested in the literature review, such as Tyler's Goal-Oriented Model, Metfessel-Michael Evaluation Model, Provus's Discrepancy Evaluation model, Stake's Conformity-Probability Model, Stufflebeam's Context, Input-Process and Product Model and Stufflebeam's Total Evaluation Model, Eisner's Educational Criticism Evaluation Model, Stake's (1983) Responsive Program Evaluation Model, and Demirel's Analytical Program Evaluation Model (Demirel, 2007; pp.179-187). In this study, the aim was to understand the overall evaluation and the differences between the program's objectives and results. The evaluation approach used in the research was the Provus Discrepancy Evaluation Model, developed by Malcolm Provus for educational program evaluation and improvement. This model has a pragmatic/utilitarian perspective and is the first of its kind. Its strongest aspects include emphasizing program definition, analyzing definitions, ensuring information flow between participants and program processes and results, and effectively using data to provide links. (Eviren, 2017, pp.63-64).

The problem statement of this research is to determine whether the OpenZeka 2021 summer internship program achieved its goals and whether a more efficient program can be proposed. The research aims to provide insights into possible problems and solutions that may arise in a short-term internship program. Additionally, it aims to thoroughly evaluate an internship program, create an original program, offer new experiences in an office setting to aspiring engineers interested in artificial intelligence and embedded technologies, identify potential problems during the implementation process of a real internship, develop solutions to those problems, and present a unique engineering internship model. This research is considered significant in this regard. Therefore, the general problem situation is the efficiency of the internship program, and the research questions related to the problem have been determined as follows.

1) What is the scope of the action plan for the OpenZeka 2021 Summer Internship program?
2) What are the thought of the interns on the OpenZeka 2021 summer internship program?
3) What are the thoughts of the interns regarding their evaluation of the company?
4) What can be said about the technical performance of the interns?
5) What can be said about the problems encountered during the operation of the action plan prepared within the scope of the internship program?
6) What can be said about eliminating the problems experienced during the implementation of the internship program?
7) What can be said about the new action plan?

## 2. Methodology

This study aims to evaluate the OpenZeka 2021 Summer Internship Program, using the action research technique. To assess the program as a whole, it is necessary to scrutinize the issues from the planning phase until the program's completion. The researcher, who is also the training manager, actively participated in the internship program from start to finish. In qualitative research, the "transferability" feature is the equivalent of the "generalizability" feature in quantitative research (Yıldırım & Şimşek, 2011, p.303).To enhance the applicability of qualitative research, it strives to impart some insights and experiences to readers towards the end of the study instead of drawing conclusions that are universally valid. In qualitative research, it is essential that the researcher observes the phenomenon with as little bias as possible and demonstrates flexibility, which are crucial factors for achieving validity (Kirk & Miller, 1986). As part of this study, we conducted interviews with potential interns from different engineering departments at various universities. We also received support from researchers on how to perform unbiased evaluations. To ensure accuracy, we used a variety of research techniques including observation, descriptive analysis, document analysis, and content analysis. This allowed us to gather diverse perspectives from both participants and methods.

To ensure the validity of our qualitative research, we collected information over an extended period of time in natural settings, confirmed our findings by returning to the research environment, collected additional information when possible, and used different analysis strategies. As the researcher, we were present during the entire process as both an educational administrator and coordinator. To ensure the reliability of our study, we first established a framework for evaluating internships, introduced the social environment and participants, and explained our data collection and analysis methods in detail.

The process of action research is structured to focus on problem-solving and is continuous in nature. It involves identifying the problem, collecting data, analyzing it, determining an action plan, implementing the plan, and deciding on an alternative or new course of action. (Yıldırım & Şimşek, 2011, pp. 335-336). According to Mills' (2000) classification, action research can be divided into two types: applied action research and participatory action research. The former is focused on addressing educational problems, while the latter aims to enhance the learning outcomes of individuals in any subject and improve their professional abilities (Creswell, 2005). During this study, attempts were made to develop solutions at different levels and make recommendations accordingly. The research method used was participatory action research, which involves participants within an institution or program collaborating to create a research design, implementing it, and obtaining recommendations for change (Bogdan & Biklen, 2003). The research aimed to evaluate the effectiveness of the internship program. To achieve this, interviews were conducted with all participants, data on intern performances and program

evaluations were collected, and various techniques such as document analysis and content analysis were used to analyze the data.

During the study, 17 individuals participated, comprising of 12 interns and 5 company officials. Among the interns, 9 were part of the regular internship program, while the remaining 3 were assigned to the company project. The interns were segregated into two groups based on their performance indicators for the training programs. Two different training programs were created for two distinct groups. The first group underwent an artificial intelligence-based training program, while the second group underwent a program that met the company's project expectations. The performance indicators for the first group included physical participation in the internship, daily report submission, process chart completion, article presentation rate, the project developed during the internship, the number of NVIDIA certificates received, and any additional voluntary work done outside the program. Meanwhile, the performance monitoring indicators for the second group included problem-solving, adapting and implementing new technologies, writing clean code, using frontend and backend libraries, developing real-time and low latency video streaming application (WebRTC) skills, hardware review skills, and creating an artificial intelligence inference infrastructure (NVIDIA Triton Inference Server Deployment) skills. The second group of interns were evaluated through various projects assigned by an experienced full-stack developer, in addition to the standard internship program. Technical performance was measured using metrics identified in a tool prepared by the responsible training engineer. The overall evaluation took into account the opinions of the interns themselves, as well as those of the responsible engineers and company managers.

This study evaluates the OpenZeka 2021 Summer Internship Program, with researchers and practitioners cooperating to guide the internship process. During the implementation process, the researcher and implementers had several discussions and identified problems. They also took notes on the program's shortcomings. For company and program evaluations, interns used a semi-structured interview form as a measurement tool. The interview form was prepared using various literature studies on internship program evaluation (Karslı, 2015; Abdul Karim, 2009; Özek, 2018), and the researcher created an original form by synthesizing the information gathered. To evaluate the company's internship program, we reviewed literature from various universities on engineering internships and evaluation forms. We prepared relevant questions and conducted individual interviews with participants using a semi-structured form. We analyzed the data collected through content and descriptive analysis techniques and reported our findings. We identified shortcomings in the current plan and addressed some of them during the process. The remaining shortcomings will be considered for the next internship program's action plan.

## 3. Findings and Interpretation

In this section, we analyze the data collected during the OpenZeka 2021 summer internship program evaluation and interpret the findings from various perspectives.

1) The initial research inquiry was, "What does the action plan entail for the OpenZeka 2021 Summer Internship program?" Within the action research, the following documents were incorporated into the action plan: (1) a chart for monitoring the process, (2) reports for tracking the study's progress, (3) a list of article presentations, and (4) a general diagram of internship duties. Firstly, the documents relating to the planning of the OpenZeka Internship Program were evaluated.

The interns are expected to complete certain topics within specific timeframes, as indicated in the process monitoring chart. These topics include: Fundamentals of Deep Learning with NVIDIA DLI, Hello AI World, Technical Platform Introduction and Applications with NVIDIA JETSON, Autonomous System Development with JetBot and JetRacer Platforms, NVIDIA Transfer Learning Toolkit, NVIDIA DeepStream SDK, NVIDIA Triton Inference Server Deployment, Introduction of Cordatus AI Platform, Hardware-optimized DNN execution of NVIDIA GPU Cloud Models on Edge devices, and Sequential Model Based Execution on Jetson. The training engineers provided the trainees with information on the topics that would be covered in the schedule. The training manager used a chart to assign topics to the trainees and monitored their progress on a weekly basis. Each trainee can use the chart to keep track of where they should be in the internship program

based on the topics and target periods. Reminders were given at specific intervals to help each intern monitor their progress and stay on track.

As part of their internship program, interns were required to submit work follow-up reports detailing their daily activities. These reports included summaries of their research, information and experiences gained from interactions with other interns and experienced engineers, as well as any problems encountered, and solutions found. At the end of each day, the reports were compiled and sent via email to the training manager. While delays in report preparation were rare, there were instances where completed reports were delivered later than expected.

To ensure a fair distribution of tasks, the company created a list of articles for interns to present based on the total number of weeks they were employed. The list included one article per week, and a chart for monitoring and evaluating the presentations was provided to the interns. Out of the 12 interns, nine were assigned to present articles. At the start of the internship, each intern received an email containing a weekly schedule of articles to present. The first articles were presented by the nine responsible interns with a maximum delay of one week. During the training, three trainees expressed that the articles' content was too complicated, while others had trouble preparing the abstract and presentation. As a result, the technique for selecting articles was modified. Previously, the training manager randomly picked articles from NVIDIA's academic publications page, but this was changed to a different method. During the internship program, the interns were instructed to search for articles on specific topics that interested them from the academic publications page. They were then asked to add the articles they found to a "article presentation list" page on Google Drive, which was shared with the entire internship group. While the interns had the freedom to choose their article topic, interviews and observations revealed that they faced some challenges during their presentations. The weekly article presentations experienced delays due to difficulties in translating technical terminology used in the English articles. Additionally, the interns had limited experience in reviewing academic articles. To improve the review process and speed things up, the training manager provided a brief presentation on how to review academic articles using a sample form they had created. The form was then shared with the interns for them to use in their reviews. It was noticed that some of the trainees utilized the suggested techniques during the article review process and found it easier to prepare their presentations after the demonstration. To enhance the submission process, deadlines were periodically extended, additional deadlines were given for incomplete presentations, and the option to present online was made available.

The internship tasks chart is designed to help track the first three documents created as part of the action plan. It also serves as a reminder for submitting social media posts, projects, certificates, and content. Sharing on social media is not required, but many interns reported feeling more confident as they shared their accomplishments on their personal accounts.

2) The second research question was "What are the interns' opinions about the OpenZeka 2021 summer internship program?"

Table 1: Themes and sub-themes related to interns' evaluation of the internship program

| Themes | Sub-themes | |
|---|---|---|
| *The role of the program in professional development* | ✓ Interaction with engineers from different fields,<br>✓ Providing an informative and developmental environment,<br>✓ Supporting career goals | ✓ An intensive learning and practice environment<br>✓ Using many tools while still a student<br>✓ Visioning<br>✓ Academic development through article review |

| | | |
|---|---|---|
| *Program efficiency* | ✓ Instructive and efficient<br>✓ Multiprocess operation<br>✓ Raising engineering awareness<br>✓ Gaining work discipline<br>✓ Integration into work life | ○ Not too much workshop style<br>○ Based on self-learning<br>○ Insufficient time<br>○ Heavy content and an intense program<br>✓ Developing a working AI application using Jetson |
| *Program meets expectations* | ✓ Quite a lot and above my expectations<br>✓ Regular follow-up was done<br>✓ The company management had a family-like approach | ○ The program was busy, we couldn't make it.<br>○ There could have been a different way of working and learning about artificial intelligence.<br>○ Lack of interaction with experienced engineers |
| *Challenges in the Program Process* | ○ Advanced education level challenged<br>○ It was an intense program.<br>✓ Challenges helped me improve<br>✓ Engineers helped solve technical and physical problems. | ○ Since I live in a remote area, it was difficult for me to come and go to the company.<br>○ Sometimes it took me a day to correct a mistake.<br>○ I was afraid to ask questions |
| *Functionality of the process chart* | ✓ Facilitate self-monitoring<br>✓ Following the correct order in topic sequencing<br>✓ A sequence was followed from simple to difficult<br>✓ Training manager support was provided for monitoring and motivation, and engineering support was provided for content. | ○ I could not easily find answers to difficult topics on the internet.<br>○ The schedule was dense, the subject content was high<br>○ Insufficient time to catch up |
| *Recommendations for the program* | ✓ At the beginning of the internship, brief information about the NVIDIA hardware<br>✓ Teamwork should be more intense<br>✓ One week should be devoted to hardware and software alone and two weeks to a project combining the two.<br>✓ Training content should be diversified | ✓ Management and engineers' ideas on how to implement the program should not overlap<br>✓ Since the program is intensive, it should be slightly reduced or the internship period should be extended<br>✓ Give a project encouraging research on the topics before starting the internship |

*Table 1 presents the themes related to the interns' evaluation of the internship program.*

The table uses a check symbol to indicate positive evaluations and a circle symbol (○) to indicate negative evaluations. The theme of the program's role in professional development includes several sub-themes, such as interacting with engineers from various fields, using multiple tools for academic development and studying articles while still a student, fostering an environment that facilitates learning and practice, supporting career goals, and providing a vision. Based on the feedback provided by the interns, the program had its strengths and weaknesses. While some interns (n=4) mentioned that they did not get the opportunity to work on hardware projects during the internship process, others (n=6) felt that their equipment usage skills improved even further. A few interns (n=2) did not express any opinion on this matter. As per Table 1, the program was evaluated positively for its instructive nature, contribution to engineering skills, provision of multidimensional working skills and work discipline, and the opportunity to develop an artificial intelligence application using Jetsons.

However, it was evaluated negatively for its intensity and difficulty, the need for more self-learning, and insufficient internship time.

For a successful internship program, it is recommended to begin with a short introduction to the NVIDIA hardware that will be utilized during the process. The program should also prioritize interactive teamwork, dedicate one week solely to hardware and software, and allocate two weeks for the project that integrates both aspects. To improve the training program, it is recommended to diversify and simplify the content. It is important for managers and engineers to have a unified approach to implementation. The program should be slightly reduced in content or extended in duration due to its intensity. Research should be encouraged on topics prior to starting the internship. The program should be designed for first-time learners with an empathetic approach. An inductive approach is recommended, and a natural project that the company is developing should be incorporated into the training. The program should be integrated into the training curriculum.

All 12 interns who participated in our company's long-term internship program expressed interest in participating again. However, only 2 interns felt that the university/mentor support was helpful, while 2 others felt it was only partially helpful, and 8 felt it was not helpful at all. Additionally, 4 interns stated that they were not ready for the profession, 3 felt partially ready, and 5 felt mostly ready by the end of the internship. Out of the 5 who felt mostly ready, 3 were hired by OpenZeka, while the other 2 found employment in different companies after interviews conducted approximately 4 months later.

The third inquiry posed was about the interns' overall evaluation of the company. The responses were compiled and presented in Table 2. It outlines the themes and sub-themes related to their thoughts. The data suggests that the interns' initial impression of the company was positive. They appreciated the NVIDIA partnerships, international commercial operations, hardware and training support, professional staff, and the exciting office environment. However, they noted that the physical space was small, which was considered a drawback. The company management raised the issue with Cyberpark but received no positive response due to high demand. Nevertheless, the company moved to a bigger office space after the internship period.

Table 2: Themes and sub-themes related to the general evaluations of the interns

| Themes | Sub-themes | |
|---|---|---|
| First impressions about the company | ✓ NVIDIA partnership<br>✓ Critical commercial operations<br>✓ Hardware support<br>✓ Education support | ✓ Expert staff<br>✓ Exciting office environment<br>Physical smallness |
| The relationship between the competencies provided by the internship process and the competencies provided by the university | ✓ I found the cameras, the Jetbot installation and their simulations related to my field of electrical-electronic engineering.<br>✓ I can relate some of the laboratory courses I took at the university to the internship process.<br>✓ Both the university courses and the internship process contributed to my problem-solving skills.<br>✓ There was almost no relationship between what I learned at the university and the internship program. | |

Table 2: Themes and sub-themes related to the general evaluations of the interns

| | | |
|---|---|---|
| Good engineering approach | ✓ Solution-oriented<br>✓ Has an inductive approach<br>✓ Curious, highly motivated<br>✓ Creating a positive environment and focused on developing the team.<br>✓ Questioner<br>✓ Durable | ✓ Determined<br>✓ Adapts quickly to changing technologies.<br>✓ Focused on the development of a product.<br>✓ People-oriented<br>✓ Able to think and see differently.<br>✓ Researcher |

Based on Table 4, it was observed that some individuals noted similarities and differences between the competencies gained through the internship process and those provided by the university. However, others stated that there was no similarity at all. Notable statements on the topic include: "The university contributed around 30% to my practical knowledge," and "Both the internship process and the university instilled in me a sense of research discipline.", In my professional life, I often use the same problem-solving methods that I learned while completing coding assignments at university. However, the integration process of industrial software and hardware was not covered in my coursework and was only available to me during my internship. During this time, I was also introduced to the field of Image Recognition and was able to improve my knowledge in this area. The C++ and Python courses I took at university also contributed to my growth during the internship. Overall, I would rate the contribution of my university education to my engineering development as 1 unit, my self-study efforts prior to starting my company as 10 units, and the contribution of my internship at OpenZeka as 50 units. In a similar vein, Islam (p.16, 2023) shared their own internship experiences, noting that while they initially faced some difficulties in their management and information systems internship, they were ultimately able to develop professionally, particularly in software and digital marketing.

Table 2 highlights important characteristics for effective engineering, including a solution-oriented mindset, inductive approach, curiosity, high motivation, creating a positive team environment, resilience, adaptability to new technologies, focus on product development, people-oriented, ability to think creatively, research skills, and a curious nature.

4) The fourth research question was "What can be said about the technical performance of the interns?"

In order to assess the technical abilities of the interns, they were divided into two groups based on their backgrounds. The first group participated in a standard internship program that focused on artificial intelligence and deep learning training. The second group, which had prior web development experience and was expected to contribute to the company project, received a different internship program. The first group's performance was monitored based on participation in the internship, daily report submissions, completion of process charts, rate of article presentations, the project developed during the internship, the number of NVIDIA certificates received, and the amount of additional voluntary work done outside the program. The results of this monitoring are presented in Table 3.

Table 3: Distribution of First Group Interns Performances According to Monitoring Indicators

| | Internship duration (working days) | Participation * /Continuation Ratio | Process Schedule Completion Rate | Daily Report Delivery Rate | Article Presentation Ratio | Number of Projects (Max.3) | Number of NVIDIA Certification (Max.4) | Additional Studies |
|---|---|---|---|---|---|---|---|---|
| S1 | 20 | .95 | .40 | .70 | .50 | 1 | 1 | 1 |

Table 3: Distribution of First Group Interns Performances According to Monitoring Indicators

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S2 | 20 | 1.00 | .60 | .80 | .50 | 2 | 3 | 2 |
| S6 | 20 | .90 | .40 | 1.00 | 1.00 | 3 | 3 | 3 |
| S7 | 20 | .85 | .40 | .90 | .50 | 2 | 1 | 3 |
| S8 | 20 | .85 | .50 | 1.00 | .50 | 1 | 2 | - |
| S9 | 30 | 1.00 | .50 | 1.00 | .67 | 2 | 4 | 1 |
| S10 | 40 | 1.00 | .60 | .88 | .50 | 1 | 3 | 2 |
| S11 | 40 | .75 | .80 | .68 | .33 | 3 | 3 | 1 |
| S12 | 30 | .50 | .60 | .67 | .17 | 2 | 2 | - |
| n=9 | | | *Total* | | | 17 | 22 | 13 |

** Participation periods were calculated for both groups according to the status of continuing to work face-to-face in the physical environment of the company.*

The data in Table 3 shows how the first group of nine participants performed during the standard internship program. The duration of the internship varied from 20 to 40 days, and most of the participants had a high attendance rate of 85% or more, with only two participants having lower rates. The number of daily reports submitted increased as the internship went on. However, the article presentation and process chart completion rates were generally below 50%, which may be because the interns had different readiness levels and the topics were difficult. Some interns also worked on tasks, competitions, or projects outside of the standard internship program based on their interests. Although there was no strict framework for the program, interns were reminded of its objectives throughout the internship.

During their internship, the interns were encouraged to obtain NVIDIA certificates in artificial intelligence and deep learning. Table 1 shows that all participants earned a total of 22 certificates, with a minimum of 1 and maximum of 4 per person. The interns also developed 17 projects using Jetbot and Jetson Nano, including dangerous object detection alarms, helmet recognition for occupational safety, real-time heat mapping, and smart piggy banks.

In addition to their project work, a group of 7 interns translated texts for blog content and analyzed current topics such as NVIDIA Isaac Sim and Omniverse (see Appendix_3). Some interns also received training in web development, including WebRTC, Javascript, and HTML (6 participants), which was reported by the responsible training engineer (see Annex_4).

The second group was assessed based on various skills such as problem-solving, adapting to new technologies, writing clean code, utilizing frontend and backend libraries, developing real-time and low-latency video streaming applications (WebRTC), inspecting hardware, and creating artificial intelligence inference infrastructure (NVIDIA Triton Inference Server Deployment). These skills were identified as performance monitoring indicators and are presented in Table 4.

Table 4: Monitoring Indicators of Second Group Trainee Performances

| | Problem Solving | Adaptation to new technologies | Clean code writing* | Using frontend libraries | Using backend libraries | (WebRTC) application development | Hardware review | Artificial intelligence inference infrastructur |
|---|---|---|---|---|---|---|---|---|

Table 4: Monitoring Indicators of Second Group Trainee Performances

| | | | | | | | | e |
|---|---|---|---|---|---|---|---|---|
| S1 | .80 | .90 | .70 | .80 | - | .80 | - | - |
| S4 | .80 | .80 | .70 | .80 | - | .90 | - | - |
| S5 | 1.00 | .90 | .80 | - | .80 | - | .80 | .90 |

**The readability and efficiency of the code are taken into account here.*

Based on Table 4, the intern's performance in hardware review and AI inference infrastructure was closely monitored. However, the candidate's progress in front-end libraries and WebRTC application development was not taken into account. The table indicates that all three candidates scored 80% or above in problem-solving, adapting to new technologies, and utilizing backend libraries.

Based on the results, the interns in the second group all scored 70% or higher on performance indicators. Tables 3 and 4 show that the second group generally demonstrated better engineering skills than the first group. This could be due to differences in the acceptance process, as the second group had higher readiness levels and programming skills upon acceptance. As a result, they were considered for employment as interns. This may have contributed to their increased motivation and performance during their internship.

The fifth research question asked about the challenges faced while executing the action plan in the internship program. The small company environment and the global pandemic posed difficulties in implementing certain measures. To overcome this, the management gave the candidates the choice to work remotely, which some of them opted for. However, most interns preferred to work in a physical setting despite the remote option being available. During the official vacation after the second week of the internship, some interns faced challenges. Some didn't have good internet access where they went for vacation, the temperatures were higher than expected, and they were away from the supportive work environment of the company. They found it difficult to take a break from work and re-adjust to the office environment upon their return. This made it challenging for company management and instructor engineers to re-implement the internship program for some of the interns who were distracted after their vacation.

6) The sixth research question was "What can be said about eliminating the problems experienced during the implementation of the internship program?".

In this research, a practice-oriented approach was utilized in order to eliminate or reduce problems through action research. To overcome any difficulties that arose during the implementation of the action plan, improvements were made, such as reducing the number of article reviews and allowing for remote work when necessary. Additionally, personal projects were encouraged, and progress was monitored to ensure the process was appropriate. Although some interns responded positively to these changes, others did not. It should be noted that systematic data collection can be difficult due to the variability of the process in applied action research, which is known to be a more flexible research method (Yıldırım & Şimşek, 2011, p.335). Unexpected events that occurred during the internship program, technical disruptions, leaves taken due to health and family situations, holidays lasting more than a week, and disruptions in the normal functioning of the program affected the variability of this process to a certain extent. Nevertheless, to reduce the difficulties and compensate for the gaps, the interns were supported by the company management and trainers for the rest of the program.

7) The seventh research question was "What can be said about the new action plan?".
The first action plan was designed during the planning phase of the internship program.

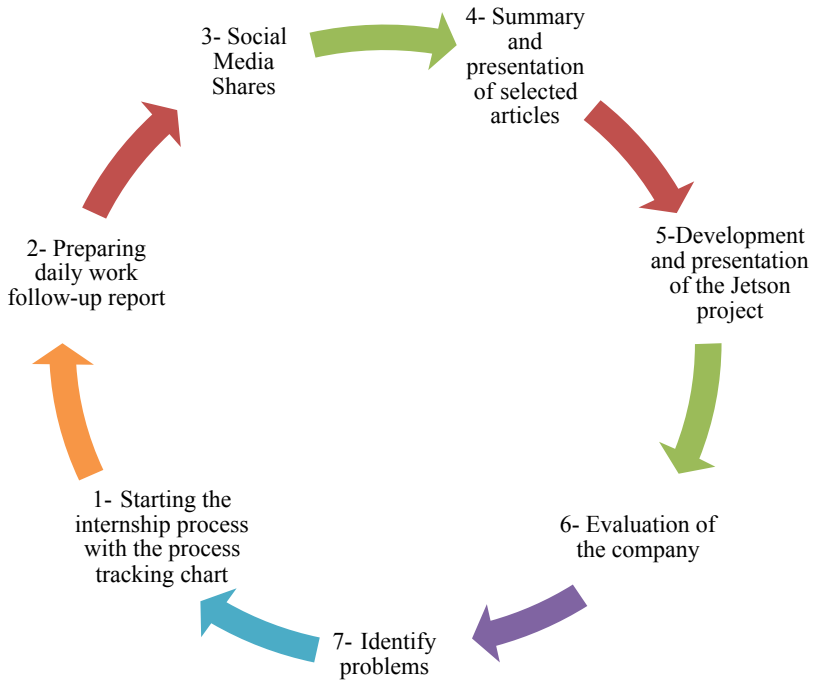


Figure 1: First Action Plan

In Figure 1, the initial action plan consists of seven tasks. These include initiating the internship process with a tracking chart, creating a daily work report and social media updates, summarizing, and presenting articles, developing and presenting the Jetson project, evaluating the company, and identifying any issues. The design covers multiple stages from planning to evaluation. When devising the first action plan, we took into account the practices of other companies in the software industry, input from field experts, academic articles (Kariya, 2002; Tan & Umemoto, 2021), and our previous internship experiences. Following a 14-week implementation, we revised some items in the original action plan. We put some of these revisions into practice during the implementation, while others were incorporated into the new design as the second action plan to be implemented during the next internship process.

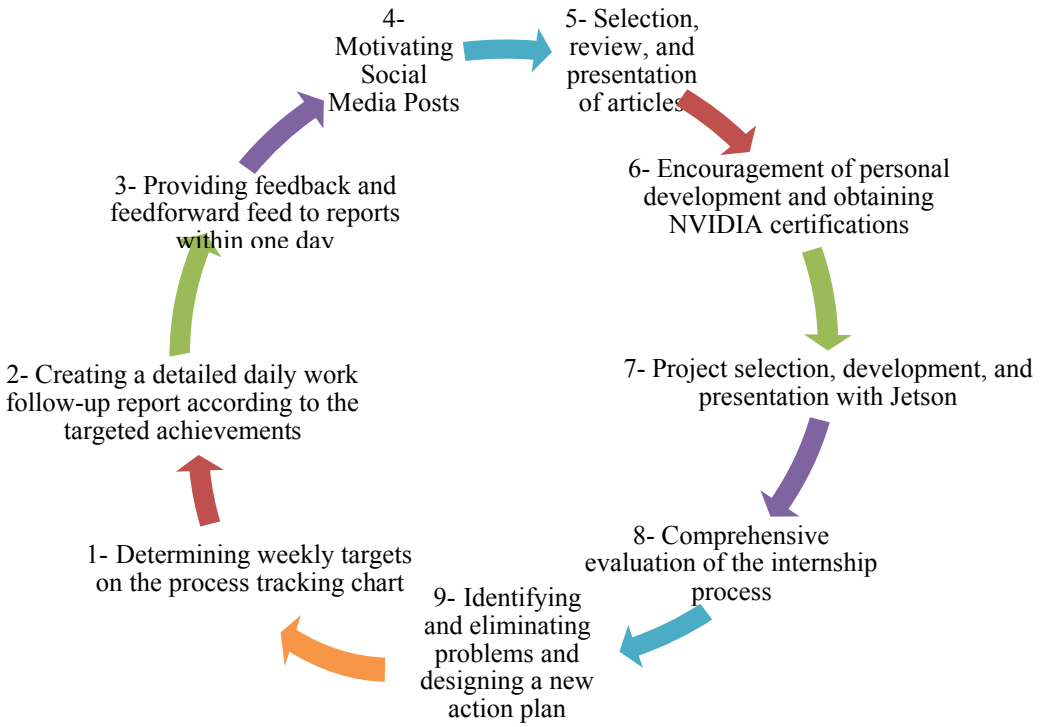


Figure 2: Second Action Plan

Figure 2 displays the second action plan, which comprises a total of nine items. The plan includes two new items - "Providing feedback to reports within one day" and "Encouraging personal development and obtaining NVIDIA certificates" - that were not part of the first plan. Additionally, the plan has been modified to include weekly goals for starting the internship process and creating a detailed daily work follow-up report based on targeted gains. The plan also ensures that the interns are responsible for selecting articles, and the evaluation process is comprehensive and includes all individuals involved in the process. The second action plan is more individualized, encourages development, and is comprehensive in its planning, implementation, and evaluation stages when compared to Figure 1.

## 4. Discussion and Conclusions

Throughout and following the internship program for OpenZeka's 2021 Summer Internship, the action plan's scope may be adjusted or amended. Certain changes and corrections were implemented during the internship, while others were incorporated into a secondary action plan. However, the interns in the program found the training content to be arduous and challenging, surpassing the expected timeframe. This suggests that the interns' preparedness and the duration of the internship, which is only 20 working days, are inadequate. The interns had a positive overall evaluation of the company, although they expressed dissatisfaction with the physical conditions. Further analysis revealed that interns who participated in the middle of the internship reported higher levels of satisfaction compared to those who participated at the beginning or end of the program. Based on the results, it appears that the interns may not have been adequately prepared for the program, which lasted for 20 working days. Overall, the interns had a positive view of the company, but were dissatisfied with the physical conditions. Interestingly, those who participated in the middle of the internship were more satisfied than those who started or ended the program. This suggests that the most productive and interactive work occurs in the middle of the internship. Going forward, it may be more beneficial to determine the start and end dates of the program based on the common good rather than individual candidate preferences. Additionally, avoiding a lengthy 10-day holiday period could potentially boost productivity. The interns have varying levels of technical ability. It has been observed that the second group of interns is more proficient than the first group, not just in the theoretical concepts learned in university courses, but also in their engineering approach. This highlights the importance of students developing their programming skills, as it can give them an advantage over other candidates when seeking engineering positions.

During the research, a senior executive from the company expressed that their motivation for operating is to fulfill their social responsibility duties and to create human resources for the company. Additionally, another official mentioned that the program accepts four times the legal limit of interns. According to the official, the company aims to develop its human resources, and as such, some interns may have the opportunity to become full-time employees in the future when certain conditions are met. In fact, some prospective engineers who completed the internship program in line with this goal and expressed interest in continuing with the company part-time were able to secure full-time employment after graduation. Kariya (2002) noted that commercial firms often utilize internships as a way to assess potential hires. Accordingly, employers considered internship programs as a more effective method for new hires than other types of recruitment. According to a study, National Instruments aims to employ 25 percent of its interns after they graduate, whereas IBM usually hires one-third of its interns. In some countries, internships are linked to corporate recruitment (Kariya, 2002). Furthermore, over 70 percent of firms in the United States tend to hire interns as full-time staff, but only around half of the interns are promoted to full-time positions (Tan and Umemoto, 2021).

In today's fast-paced world, it's crucial to gain practical experience through internships to meet industry demands, develop global engineering skills, and build a strong foundation in humanities and applied sciences. According to Kariya (2002), Joe Marks, the head of Cambridge Research, believes in a short-term return on investment rather than a long-term one. He suggests that interns can provide some institutions and firms with a cost-effective way of getting work done. An internship program was announced by OpenZeka a month prior to its commencement. It was emphasized that the program would be most effective for interns who managed the process well. Those who successfully completed the program's determined topics received certifications for Fundamental of Deep Learning and Getting Started. Upon completion of their projects, they applied to the NVIDIA Jetson Project page for publication of their studies and were awarded the AI Specialist Certificate for

their accepted projects. The internship process is an effective way for engineering candidates starting their professional life to gain a social environment, improve their skills and acquire new ones (Kocabatmaz, 2011, pp. 17-18).

According to a study by Renganathan, Abdul Karim, and Su Li (2012), students had a positive evaluation of the industrial internship program and found that hands-on experience during the internship led to more effective learning. The study also identified the operational and administrative efforts of the organizers and the role played by the host company as important factors in determining the success of the program.

According to Ozek (2018), the success of an internship program depends on the level of cooperation and commitment from intern students, partner companies, and university academic staff. In addition, the intern's intrinsic motivation and the role of faculty are also crucial factors in a successful internship program. Prabhu (2016) emphasizes the importance of faculty in ensuring the program's continued success.

A properly run internship program can have positive outcomes for the company, educational institution, and participating students in both the short and long term. Studies have shown that the quality of internships has a positive impact on future employment success, and that a student's ability to adapt their career goals is a key factor in their overall success, alongside their proactive personality traits (Pan, Guan, Wu, Han, Zhu, Fu, & Yu, 2018).

Companies with successful internship programs can show how effective their internship process is. A study found that technology and engineering students gained valuable professional experience and skills through summer industrial internships. The training providers within the company were very supportive of the program and provided students with real work experience. Managers also stated that a well-executed internship program helps students gain a better understanding of their job, job performance, and work quality, as well as the opportunity to develop social skills.
As of October 2022, the second batch of engineering trainees are currently employed full-time at the firm. The first group of interns have since found employment in various companies after graduating. Based on feedback from both groups of interns one year after completing their internship, although there were some setbacks, overall, the internship period was successful and had a positive impact on their professional lives.

In this study, we conducted a thorough evaluation of the OpenZeka 2021 summer internship program from the perspectives of interns, employees, and managers. The program provided opportunities for interdisciplinary interactions among engineering disciplines such as computer, electrical and electronics, mechanics, electronics and communication, and mechatronics, regardless of the intern's field of study. Our goal was to develop a distinct model for an internship program implemented in a software company's physical environment and offer insights on what not to do in a good internship program and how to improve it.

## 5. Recommendations

For researchers evaluating the Internship Program, some suggestions include using the practice-based action research technique as the methodology. Additionally, researchers can explore different methods and techniques including review studies with large-scale field surveys, quantitative studies using a Likert-type graded scale, or case studies. As for companies evaluating the OpenZeka Summer Internship Program, suggestions were made following examinations and interviews. It is recommended that the company determines the start and end dates of the internship within a reasonable timeframe. This ensures that the program runs smoothly and does not interfere with the work of the company's engineers. It is best to avoid a wide range of dates to prevent any disruptions or gaps in the program. Before starting the internship program and selecting candidates, it's important to assign some small tasks to them ahead of time. This will help the candidates come to the program better prepared. If necessary, interns can be divided into smaller groups based on their programming skills and readiness levels. Encouraging interaction within and between these groups will enhance the overall experience. During each day of the internship, instructor engineers are required to develop and execute a comprehensive training program for all groups, lasting a minimum of 15 minutes. Failure to complete assigned tasks or projects on time may negatively impact the intern's evaluation grade.

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# Motorhomes as a Housing Alternative for the Indonesian Millennial Generation

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**Abstract**
Motorhomes/campervans are a long-standing fad that is currently making a resurgence in all parts of the world. Because of the versatility of the motorhome, this lifestyle has grown in popularity, not only among hippies, but also among families who wish to have fun or live a nomadic (moving) existence, especially with the rapid rise of the Internet of Things. We can learn from the Covid-19 pandemic that work and study can be done anywhere, whether at home, in recreational spaces, in third rooms, and so on. Motorhomes can now be purchased at reasonable costs. Furthermore, the motorhome can be customized to meet your specific demands and functions. Motorhomes can be created from simple automobiles using any car foundation, such as an MPV, Van, SUV, Middle Size Bus, Full Size Bus, or even a sedan, rather than full size RVs with big proportions and luxurious equipment. The purpose of this study is to define the motorhome/campervan concept and its potential as an alternative housing type. Furthermore, the potential is fairly large for Indonesian millennials, who appear to have a lot of issues on housing ownership mostly because the affrodability (economic) aspect and also considering the raising on nomadic and flexible lifestyle. Motorhomes are an excellent option to economical housing since they are mobile, have flexible layouts, and provide a comfortable living space especially for Youth Indonesia's Millenial who's carving for a unique experience.

**Keywords:** Motorhome, Flexibility, Nomadic, Dwelling, Millenials

## 1. Introduction

### *1.1 Motorhome Trends and The Housing Ownership Problem for Young Indonesian*

Motorhome is a popular mode of transportation throughout the world. In some countries, a motorhome is also known as a campervan or an RV. Initially, the train Motorhome was established by hippies who had a desire to travel from one location to another. The flexibility of motorhomes has increased the popularity of nomadic living, not only among hippies, but also among other groups that want to expand their horizons or pursue their dreams. Currently, with the advancement of technology, mobile lifestyle activities are becoming more feasible. More specifically, the Internet of Things, in which the internet can collect data and improve nearly every aspect

of human life. If the quality of one's work has become a defining feature of one's lifestyle, this may now be addressed with the addition of a high-speed internet connection. Humans can boost their productivity while traveling by utilizing Big Data (Internet) technology.

We can learn from the previous conditions of the Covid-19 pandemic that work and study can be done wherever, whether at home, in recreation spaces, in third rooms, and so on. This is done to prevent the virus from spreading further by minimizing physical human contact. Work is no longer constrained by location or time as long as goals and objectives can be met and executed successfully. This is how the phrase "Digital Nomads" came about.

Digital Nomads are workers who frequently travel or migrate from one location to another to work or study. They make advantage of the Internet of Things to boost efficiency while working or learning from anywhere. The fundamental idea is to provide for a great deal of flexibility in the work or study process, both in terms of location and time (Karsten, 2022). Working from home (WFH) is a word that is gaining popularity. This benefits not only workers, but also businesses that do not need to provide physical work space in order to save operational costs.

Before delving into the topic of motorhomes, it would be prudent to perform a study of excellent residential standards in terms of various philosophies. Aside from that, an analysis that underpins the requirement for housing can be performed. So that we can comprehend the fundamental nature of residential activities and the fundamental necessities of a residence. This will serve as the foundation for a feasibility study on motorhomes as an alternative housing type for Indonesian Digital Nomads, a trend that is gaining popularity among the millennial generation and younger. As a result, appropriate exploration will be accomplished in efforts to develop this discourse because it fulfills this essence.

*1.2 The Housing Ownership Problem for Young Indonesian*

It is intriguing to view motorhomes as a new inexpensive typology among Indonesian millennials, since conventional home ownership by the Indonesian millennial generation (born 1976-2001) is now very low. According to PUPR Ministry data from 2019, 81 million Indonesian millennials do not own a home. According to a survey of 3000 respondents, over 41% cited financial concerns as the primary issue.

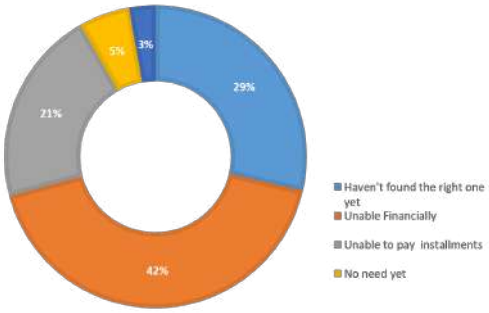


Figure 1: The Reasons for Young Indonesia to Not Owning a Home Yet
*Source: Indonesia Ministry of Public Works, 2019*

*1.3 The Indonesian Digital Nomads Phenomenon*

The Digital Nomads phenomena is spreading throughout the world, including Indonesia. This is exacerbated by the impact of the Covid-19 pandemic, which has resulted in severe limits in many aspects of human existence, including work. Work is traditionally done face to face in the workplace, both in the office and in the field, requiring people to physically engage with one another.

However, given to the pandemic's restrictions on physical contact, some organizations have established shifts and modifications in work habits. Fortunately, the internet of things is assisting in the smooth transfer of these

developments. There are numerous options available while surfing the internet without sacrificing work productivity. Meetings can be held virtually, as can collaboration with cloud data systems and a variety of other tasks.

With the spread of the internet of things, numerous previously unknown vocations have gained popularity among people, particularly the younger population in Indonesia. As the primary position, this profession is primarily reliant on internet-based technologies. Social media marketing, retail, bloggers, vloggers, and many more traditional vocations have given way to technology-based ones. Work is no longer constrained by geography or time. Work is becoming increasingly important and results-oriented.

In Indonesia, Bali is a popular tourist destination that is well-planned for digital travelers. This is due to Bali's extensive work infrastructure and recreational facilities. Aside from that, the government has designated Bali as the primary destination for digital nomads, both domestic and international, through work from Bali. Apart from starting a new job, the government wants to rebuild Bali's gairah, which is now under construction due to the Covid-19 pandemic. As a result, it is hoped that by having a digital nomad, the general public will benefit from it (Rahayu, 2021).

According to Wiranatha dkk's 2020 study, there are several factors that contribute to Bali's status as a strategic digital node, including (a) Low cost of living, (b) a variety of facilities, (c) the friendliness of the local community, and (d) a variety of weekly or monthly events. Employment and its consequences are prohibited by Executive Order No. 13 of 2003, such as working conditions and usage, are altered. According to several sources, "tenaga kerja" refers to "anyone who can perform work in order to obtain goods and/or services, whether for personal or societal benefit." This definition can be used to categorize Indonesian workers as digital nomads. They usually make money by providing online services (Pradipta 2021).

*1.4. The Potent of Motorhome as an alternative dwelling alternative for Indonesia's Millenials*

This study's idea is that motorhomes can be an excellent alternative housing type due to its flexibility, low ownership and operating costs. Motorhomes can be built on a variety of platforms, ranging from low-cost cars to high-end vehicles. As a result, this can be tailored to the available budget. Aside from that, RVs provide flexibility in the form of places that can be changed as desired, in keeping with the growing trend of digital nomads, in which the younger generation can live, work, and travel from anywhere, and can be combined with expedition activities.

On the other hand, there will be significant constraints as compared to traditional residential typologies.

## 2. Method

The purpose of this essay is to investigate the possibility of motorhomes/campervans to become an alternative housing typology that is friendly, affordable, and consistent with the characteristics of Indonesian Millennials. This essay investigates how RVs can serve as a bridge between residential comfort and flexibility and affordability. This paper's hypothesis is that motorhomes can be an alternate housing type for Indonesian Millennials, taking flexibility and financial constraints into account.

The first section is an examination of the function of the motorhome, with a focus on how the housing program can be tailored to the motorhome's limited space, as well as how the motorhome - its user and its surroundings - responds to the program. The normative programs that are often present in conventional residential units are then studied using various theories and then crossed with motorhome capabilities to investigate the possibilities that will be produced. This is done to ensure that the motorhome can work as a compact, comfortable, economical, and versatile dwelling. The conclusion follows next. The final portion will include a discussion of issues that could become research domains in the future.

The majority of the information gathered comes from meta-data approaches. The author attempts to assemble similar data sourced from diverse literary sources before doing data analysis.

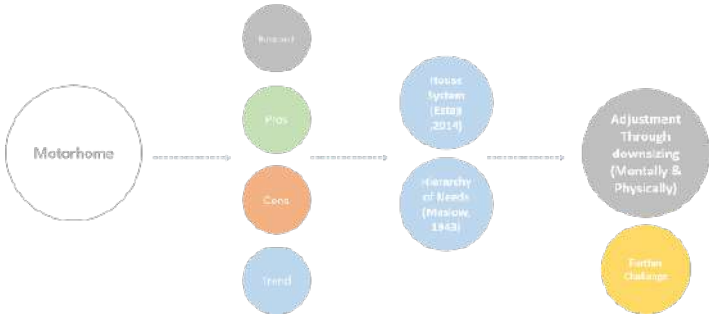


Figure 2: The Research Scheme

*Source: Writer Analysis*

## 3. Discussion

### *3.1 Indonesian Motorhome Phenomenon*

In recent years, interest in motorhomes/campervans has grown in Indonesia. Learning from the Covid-19 Pandemic is extremely important. With restrictions on human activities that need physical interaction, traveling or living in a campervan has become the primary option. This is also due to changes in the work system, which was formerly restricted by location and time, becoming more flexible. Aside from that, the younger generation in Indonesia values its presence and unique experience, notably the ability to live while moving from one location to another without sacrificing productivity at work. However, motorhome users in Indonesia appear to be dominated by leisure purposes, rather than habitation or residence for a specific period of time.

"For those who want to live in a motorhome/campervan but don't have one, there are currently several campervan suppliers in Indonesia that you can rent from." One well-known example is the Jogja Campervan. There are several tourist destinations to explore, as well as various styles of campervans to rent. In addition to the campervan, renters will receive a tent, mattress, folding chairs, plates, glasses, cutlery, portable stove, and Teflon" (Kumparan, 2022).

The Indonesian Campervan Community (CVI) is one of several Indonesian motorhome communities that discuss and exchange information about the world of motorhomes/campervans. One of the qualities of CamperVan Indonesia (CVI) members is that they do not discriminate between automobile kinds and brands, and everyone is free to adapt his or her vehicle to meet his or her own preferences and needs. Even when indulging in outdoor activities, this community believes that "Home is Where We Park the Car" (Tikum.id, 2021).

### *3.2 Indonesian Motorhome Affordability*

One of the reasons why motorhomes can be a viable alternative housing for young digital nomads in Indonesia is the vehicle's low cost. The type of vehicle can be tailored to your specific requirements and budget. Vehicles that can be used as RVs do not have to be new; they can alternatively be created from good-condition secondhand vehicles. There are numerous sorts of cars on the market, ranging from enormous vehicles with a lot of capacity to small vehicles with limited capacity. The costs of acquiring vehicles also vary substantially, ranging from 30 million to more over 1 billion Rupiah.

According to Carmudi.com, there are a number of low-cost automobile options that can serve as the foundation for a motorhome conversion. These vehicles include the following: (a) Daihatsu Grand Max (60-120 million), (b) Chevrolet Trooper covered (40-90 million), and (c) Hyundai H-1 (150-300 million). Nissan Evalia (60-90 million) (30-50 million) Kia Carnival Suzuki ATV (85-130 million). Aside from that, there are a variety of different vehicles to pick from, such as the Suzuki Hijet, Carry, or VW Combi. Currently, Alphard, Elgrand, Hiace, VW Transporter, and Caravelle are available. Isuzu ELF, Mercedes Benz Vito/ Sprinter, and other large vehicles. It is even possible to turn a regular car into a motorhome with a few alterations.

Figure 3: Left: 4x4 Motorhome. Right: Family Motorhome
*Source: Kompas.com*

According to an interview with the Managing Director of Karoseri Delima Jaya Group conducted by Kompas Otomotif, the cost of converting a vehicle into a motorhome varies substantially. This is determined by the type of donor vehicle and the required amenities. The cost of a car with a basic minibus ranges between 25 and 55 million rupiah. 125-185 million for a little basic truck. And roughly 300 million rupiah for large-based autos. There are seven feature options that can be adapted to the needs of purchasers, namely: (1). Type of generator (2). (3) split/auxiliary AC. Awnings, either automatic or manual (4). There are five jack stands/car holders. cooking pantry and cooking equipment with gas installation (6). Toilet with pump installation and water tank (7) (shower, toilet, sink, mirror, hanging shelf). Table with adjustable height. [14]

If the changes are made independently rather than through an established body shop, the expenses may be lower. However, the conversion must be carried out carefully and thoroughly through this system so that the results and expenditures incurred are in accordance with the plan. Aside from that, the ability in terms of manufacture and, of course, additional work must be considered in the independent conversion procedure. However, this can be avoided by enlisting the assistance of a carpenter or general mechanic who is not required to specialize in working on RVs.

Laksana carrosserion X Baze's work is one of the conversion works available in Indonesia. The Mahamotorhomes motorhome was constructed from two bases, particularly the Isuzu Targa base (Family type). Meanwhile, the Adventure model is based on a Nissan Navara 4x4 double-cabin truck with improved off-road capabilities, allowing it to reach destinations with more diverse terrain conditions. The conversion process, excluding the vehicle price, is estimated to cost $300 million.

The low operating costs of a motorhome are one of the factors that entice individuals to live in one. The operational costs incurred vary greatly depending on how frequently you move from one location to another, the distance traveled, the amount of electricity and water used, and the cost of parking or renting a motorhome stop (if any), but most parking is free. The fuel consumption range of the car is 5-15km/l. This fuel factor can be used as a starting point when deciding which automobile to convert.

Figure 4: Delima Jaya Carrosserie Motorhome Prototype
*Source: Gridoto.com*

A generator can power the motorhome's electrical system. Generator types vary substantially in terms of pricing. The Domestic PGE121 Portable Inverter generator is one example of a generator on the market. This generator costs around 18 million rupiah. This generator, which uses Sine Pure Wave technology, can power laptop computers, refrigerators, electric coolers, and other electronic items in RVs. The PGE121 is suitable for travel

because to its telescoping handle and strong wheels. This generator has 1800 VA of power, has relatively small dimensions of 32 x 43 x 53 cm, and weighs 26.5 kg.

*3.3 Normative Dwelling's Program*

Housing is an important component of the human life ecology. Life in an ecosystem, according to Estaji (2014), [4] consists of two variables: variables that can be predicted (Fixed) and variables that cannot be predicted. Fixed variables are components of the human life cycle that do not change or vary only slightly. The basic qualities and properties of an object are represented by fixed variables. Meanwhile, the factors do not remain constant (change), necessitating adaptation and flexibility in responding to situations and surroundings. Understanding the fundamental nature of a dwelling is required in terms of housing. What are the citizens' expectations? Housing, on the other hand, must be able to adapt to the current context, both socially, environmentally, culturally, and so on, in order to work properly.

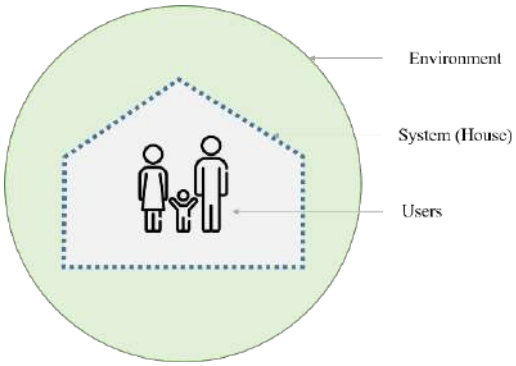


Figure 5: Dwelling System
*Source: Edited from Estaji (2014)*

A house becomes a setting for its residents' diverse needs and activities. The type of house has an impact not only on human activities within it, but also on the larger ecosystem environment. The dwelling is anticipated to be able to respond to multiple situations at the same time, both within and externally. A house should be able to meet all of its tenants' requirements and desires. In essence, housing can provide a safe and comfortable environment for its people to return home. However, the embodiment and necessity for habitation might be characterized in a complicated way. According to Maslow's Hierarchy of demands hypothesis (1943) [3,] humans have a priority level of demands that must be satisfied first when meeting their needs.

This theory has five degrees of needs. The most basic level is physiological needs, followed by the need for security, followed by the need for love and belonging, followed by the need for esteem, and finally by the need for self-actualization. The most fundamental level is an inherent necessity for every human being. Meanwhile, the drive to actualize oneself and demonstrate one's existence is at the highest level.


Figure 6: The Hierarchy of Dwelling Based on The Maslow's Hierarchy
*Source: Edited from Estaji (2014)*

According to the preceding hierarchy, a physical dwelling is a shelter that provides and accommodates different basic human needs. Housing, according to ideal standards, is not only a place for refuge and activity, but it is

also an item that may assist its people in maximizing their personal potential. Estaji, 2014 [4]. Several elements, such as environmental aspects (how inhabitants interact with their surroundings), cultural conditions, trends, and so on, will continue to evolve in order to maximize a user's personal potential. In this scenario, there has been a shift in perceptions about the concept of a dwelling, particularly among Indonesian millennial digital nomads. Permanent home ownership is hampered by a variety of factors, including a lack of cash, land, and the millennial generation's attitude toward housing. This is what is fascinating to investigate: how housing building may address these issues and challenges.

According to Hillier's (1984) theory of space syntax, the concept of space may be divided into two categories: space as a background for an activity and space as an inherent part of it, notably moving through space, interacting with other persons in space, and seeing space from a point in it. The second is that human space is not about a single area, but about the interactions of numerous spaces that comprise a whole system. Hillier refers to this as "spatial configuration." Estaji (2014). [4] According to the foregoing theory, space is not only the background for an action, but it is also an essential thing that merges with an activity. Space is therefore characterized not only by its own scope, but also by the connectivity of that space with other spaces in a system. As a result, the notion of space becomes quite varied and flexible in terms of adjusting and responding to context.

## 4. Discussion

Motorhomes can virtually fulfill all areas of Maslow's theory of human wants, although their coverage is selective rather than comprehensive. Motohome is not capable of meeting all requirements at any rating level. A motorhome can serve as a shelter on the first level (physiological needs). At this level, the motorhome meets the occupants' basic necessities. At the second level, RVs can also meet some safety requirements, albeit they have significant drawbacks when compared to permanent houses. Motorhomes can also meet the livability aspect criteria at the third level. Motorhomes will be able to boost usability and creative use of space in this regard. So that the residents can make the best use of the existing areas. Motorhomes, on the next level, not only provide basic housing demands, but also provide a pleasant (unique) living experience. In the last stage, RV occupants might actualize themselves and demonstrate their existence by delivering a pleasant experience for the tenants.

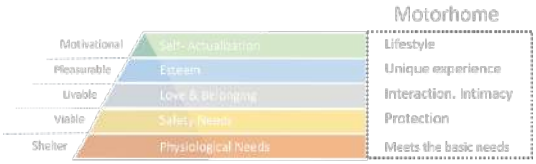


Figure 7: Motorhome on The Dwelling Hierarchy

*Source: Writers analysis*

Motorhomes are another sustainable dwelling option. From an environmental standpoint, motohomes have a negligible influence on the land. This aligns with Glenn Murcut's architectural manifesto "Touch the Earth Lightly." This allows for a reduction in the negative impact that motorhomes have on the environment. A house must meet certain basic characteristics in order to support the comfort and daily activities of its residents. When it comes to the size and minimal space available in a motorhome, digital nomads who want to live nomadically in a motorhome must make adaptations (downsizing). This is owing to the vehicle's limited room. This must be solved by comprehending the significance of daily activities at home.

Small spaces in the car interior must be structured or built in such a way that they may satisfy the occupants' diverse needs. When the vehicle is halted, extension scenarios can be added to the vehicle's outer perimeter. Another item to consider is the utilization of built-in and retractable furniture. It is believed that with careful planning and design, a mobile living experience may be built that can meet basic life necessities while also providing unique comfort and experiences.

Further research would be fascinating to observe how motorhomes are not only utilized as temporary houses that move from one region to another, but can also offer an alternative for living in a certain spot for a longer amount of time, whether monthly or yearly. This is done, of course, by taking into account and examining the land acquisition strategy, whether on a lease or ownership basis, with a specific scheme.

**Author Contributions:** the author is expected to have made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data; or the creation of new software used in the work; or have drafted the work or substantively revised it; AND agrees to be personally accountable for the author's own contributions and for ensuring that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and documented in the literature.

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