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**Short Paper**

# Development and Evaluation of Portable Oil Density Scale Device

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## Abstract

*Purpose* – The study was designed to develop a Digital Oil Density Scale Device for collecting oil density that would help environmentalist gather needed data in a shorter period of time. The Digital Oil Density is capable of checking the oil sample through a liquid sensor and weighs the oil density present in a water powered by a power bank that supplies 2000mA. The result is displayed in the unit of gram per cubic centimeter (g/cm3). A hard copy of the result can be produce using built in thermal printer.

*Method* – To gather preliminary information, the researchers conducted interviews and group discussion with the end users from the Department of Environment and Natural Resources (DENR) and local Municipal Environment and Natural Resources Office (MENRO). Related studies and literatures were reviewed and hardware and software specifications were identified in the development of the device. In the development process, the agile model was used. The descriptive design was employed through a purposive sampling of (n=60) evaluators from two groups of respondents; environment workers as Subject Matter Experts (SME) and Information Technology (IT) experts from the academe and the industry.

*Result* – The evaluation of the Digital Oil Density device was patterned after TUP evaluation instrument for hardware prototype consisted of Functionality, Durability, Economy, Safety and Saleability. The overall result obtained was "very good" cut across the two (2) groups of evaluators; environmentalists and IT experts. The functionality test exhibited ease of operation and convenience in using the device. More so, the device safety exhibited absence of faulty from electricity, sharp edges and a provision for device protection is present.

*Conclusion* – The developed device for collecting oil density samples have meet all requirements in terms of all needed functions and characteristics. The device lessened the time and effort needed to transport oil samples to distant laboratories with its compact size and portability. It gives results at the same time of testing of oil for its density.

*Recommendations* – The researchers recommend that an internal power supply and a solid carrying case for easier portability may be built. The users from the DENR and MENRO shall undergo capability training to properly equip with the functionalities of the device. The researchers also suggest that a future research can be conducted such as assessing the efficiency of the device.

*Research Implication* – The Digital Oil Density device is useful and can be a great help to not only environmentally concerned citizens but also it can teach other potential users to be aware of the dangers when oil is present in water. The use of this technology can synergize the academe and the environment sector in working together in addressing environmental issues.

Keywords: *Oil density scale, liquid sensor, environmental sustainability*

## INTRODUCTION

Oil spills are environmental issues affecting all of us. These events can be man-made or occur as natural phenomena. The Philippines utilizes marine life and uses it for various purposes. The countries labor force has around 5% that earns a living coming from fisheries. To breakdown the workers – there are 69% of municipal fisher folk, 25% are in the agriculture area, and 6% are involved in the commercial fishery (FAO, 2016). With these numbers, it becomes evident that oil spills will cause severe damage if it were to infiltrate both the sea and the local freshwater resources. The study, development and assessment of oil density scale, is a scale that measures the density of oil in water.

Oil spills pose danger to living things in the affected areas. Oil and water do not mix. Oil and water are two very different substances, less dense than water. Archimedes' Principle, states that buoyant force, the net upward force on any object with mass. It doesn't matter whether that object is placed on water or any fluid or liquid. The evidence can be seen in a visual example, and it proves that a substance or matter, which has lower density, can float on water. The research study specifically revolves around the measurement of oil density, which the device will do. The Digital Oil Density Scale is a portable device that can be carried to the oil spill site. The device focuses on measuring the density of oil. The collected sample is purely oil and no other substance, such as water, can get mixed in it. The device does not proceed to calculate the oil density once it detects the presence of water within the collected sample.

## LITERATURE REVIEW

Oil is a viscous thick matter that is harnessed underneath the earth from fossil rocks which were buried millions of years ago and this is known as crude oil when harvested. Helmenstine (2019) noted that density is measured in the unit of grams per cubic centimeter. It is known that oil density is a more common case on water than in land because of the rarity of land oil spills. It is due to the fact that petroleum products are transferred by sea voyage. Unfortunately, because of the rarity of land oil spills, minimal information on how to collect oil from the ground has been developed.

Nonetheless, as most oil spills occur in bodies of water, more attention is given to it, particularly an onsite gadget that can measure the density of oil in water. Dorfman (2000) noted that densities of different substances include a variety of oils. It implies that variations of oils and various compounds are mixed with different densities and is only possible with the absence of water in the oil and its mixtures. Hence, computing for the density of oil can only be done in the absence of water. For reference, a collection of plain oil and oil mixtures are listed in a table below.

Table 1 explains the list of possible powdered substances and variety of oils which can be mixed together. It also shows the measure of density for each substance. Oil density is the computation of the mass and volume the matter can occupy. Oil density can be measured in grams per cubic centimeter simplified as g/cm3. Dizon (2012) maintained that the denser the oil present in the area the thicker the fumes it releases. The dense oil releases toxic fumes that can suffocate people and other living beings exposed to it for a long period of time.

Table 1. Table list of oil samples in Dorfman (2000) oil measured in g/cm$^3$

| Oil | Measured in g/cm$^3$ |
|---|---|
| Cooking oil / Plain coconut oil | 0.9556 -0.9700 |
| Cooking oil with powder mixture (flour, corn starch, potato starch, baby powder) | 0.9851 – 1.0120 |
| Motor oil | 0.8102 – 0.9561 |
| Olive oil | 0.9180 – 0.9310 |

The study of oil density was first conducted in the Philippines from 1905 to 1924. It was also during this period that petroleum exploration in the Philippines begun. On the other hand, other countries studied oil viscosity earlier. Sella (2017) reported that the first Oil Viscosity Meter was first invented by Leo Ubbelohde a German Chemist (1877 – 1964). The idea was drawn from another machine called Engler's viscometer.

Moreover, the toxicity of oil depends on oil density. For petroleum product at its raw state, it is highly toxic and can suffocate a person exposed to it less than 1 hour. In this regard, the research aims to develop a device that can calculate, measure and display the oil density. The device is set only to measure pure oil. The device will be smaller and more compact and will be attached to a mini thermal printer for printing of the hardcopy of the results. Also, concept device will be build with liquid sensor. It will be used to determine whether water is present in the oil samples. If water is detected in the samples, it must be replaced with pure oil.

## METHODOLOGY

The study employed the descriptive development approach to record and gather data. The purpose of descriptive research design is to describe, explain and validate the characteristics and objectives of a specific group or population (Almeida, Gaerlan & Manly, 2016). In this study, the purpose is to gather and collect present facts concerning the hardware quality criteria on functionality, durability, economy, safety and saleability. IT experts evaluated the system from the academe and from the industry and environmentalists who served as subject matter experts (SME) of the developed system.

### *Hardware Methods*

1. Planning

For the Agile V-Model hardware method, planning is the step by step requirement dealing with manipulation of the probable outcome of the developed prototype. This phase required that gathering of the materials needed in the production of the prototype presented to the clients. Also, this phase is where the organization of thoughts takes place.

2. Designing

In the designing phase the components are arranged neatly, and the physical, tangible shape of the prototype was created. The resulting device is small, compact and portable – almost the same size as a regular AVR (automatic voltage regulator). This design was decided based on portability and ease of carrying the device in any location.

*Design of the Digital Oil Density Scale*

The developed prototype was inspired by the oil viscosity meter of Ubbelohde (as cited in Sella, 2017). In this regard, the created schematic diagram presents the design of the prototype. As shown in Figure 1, it is perceived that a tube oil sample shall be placed in a load cell. Load cell weighs the oil sample from the container which is interpreted and amplified by hx711 chip. Codes are loaded in Arduino Uno R3 which is responsible for the calculations of oil in a water and its result is seen in the LCD screen.

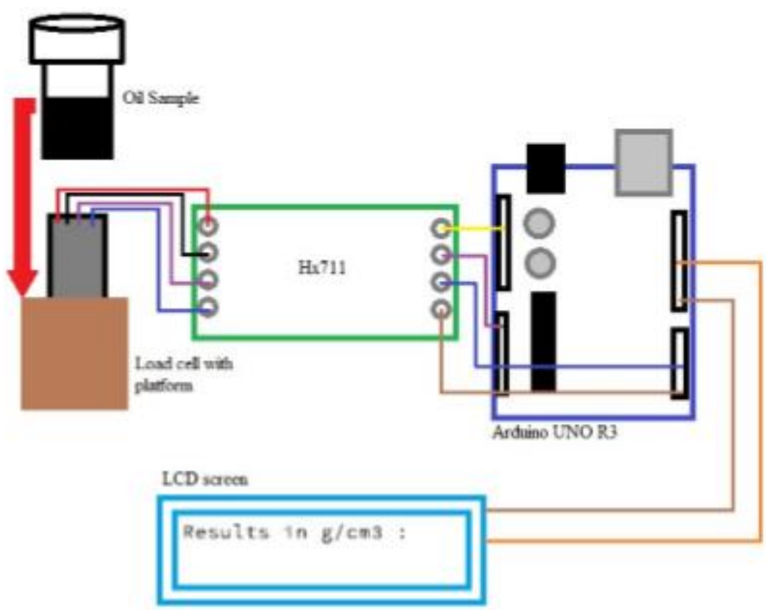


*Figure 1.* Shows the Schematic diagram of the Digital Oil Density Scale and where to place the oil sample

The process used in the development was Agile, which is a five-phased model, as shown in Figure 2. Agile is a process that promotes continuous iteration of development and testing throughout the software development lifecycle of the project. It is an approach to software development under which requirements and solutions evolve through the collaborative effort of self-organizing and cross-functional teams and their customer(s)/end user(s). It is anchored on adaptive planning, evolutionary development, early delivery, and continual improvement, and it encourages rapid and flexible response to change.

During the planning stage of the project, project requirements, such as its essential features and basic characteristics were defined. In the design phase, the overall architectural design of the project was drafted. The actual building of the project was in the development phase; the project was built through coding. After finishing the project, the finished product would undergo testing and debugging to find errors on the project. The project was verified and deployed on its release phase, and on the last phase, the project will undergo constant maintenance and improvement through user feedback.

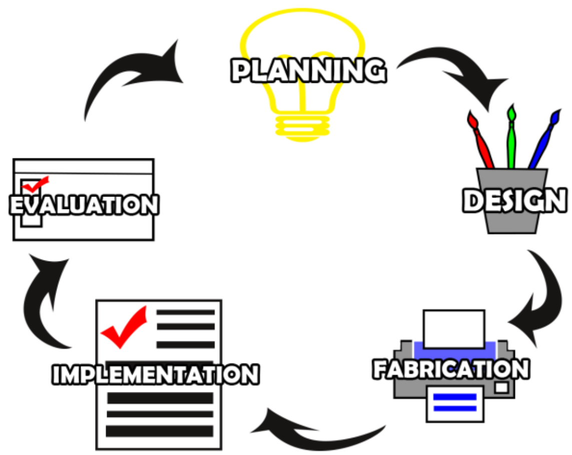


*Figure* 2. Visual representation of Agile V- Model method for hardware development

Figure 3 below shows the block diagram for the construction and the connection of each component within the Digital Oil Density Scale. The power supply being referred to is a power bank capable of powering the device which is connected to the Arduino UNO R3 board. Liquid sensor is connected to the Arduino board in order to share the needed energy for it to function. The LCD screen and the mini thermal printer are also connected to the board to be able to receive energy. Internal components are wired and glued to keep them in place.

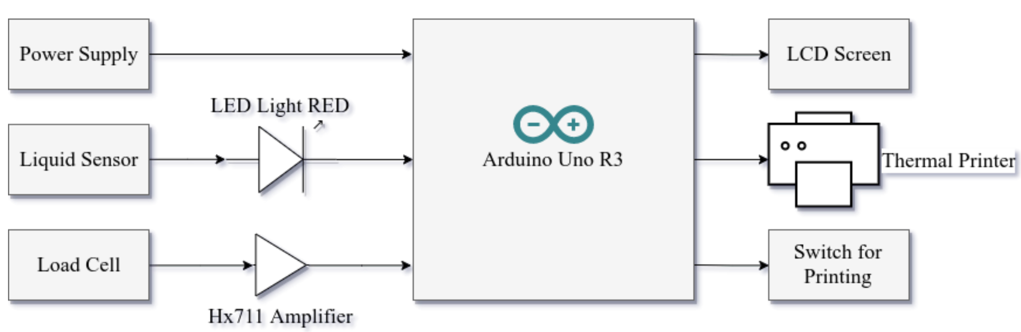


*Figure* 3. Block Diagram of Digital Oil Density Scale

3. Fabrication

Program codes were uploaded to the Arduino board. The codes were the formula for computing oil density. Additional codes were also included for the function components, which are to be operated by clients.

4. Implementation

Device was tested and approved by local environmentally focused facilities which gathered a very satisfying result.

5. Evaluation

Two groups of evaluators examined the device. These were IT professionals from the academe and IT industry and Subject Matter Experts (SME) from the environment sector. After their evaluation, the evaluators came with the conclusion that the device can perform its assigned tasks well, and it was approved to be of use.

***Population and Sampling Technique***

*A. Functional Acceptability of Hardware device (Hardware Development Standard) from the Perception of Environmentalists*

The study used descriptive statistical sampling method for hardware device evaluators. In this sampling method, researchers selected subject matter experts that were conveniently available. The sample population of the study was comprised of 30 environment experts from the fixed quota of 60 evaluators.

*B. Functional Acceptability of Hardware device (Hardware Development Standard) from the Perception of IT Professionals from the Academe and the IT Industry*

The hardware device was also evaluated by thirty (30) IT experts selected from the academe and industry. Fifteen (15) Information Technology (IT) experts were randomly selected from the industry, fifteen (15) were from IT faculty members from different schools in the province.

***Research Instruments***

The study used a standardized questionnaire for hardware quality adapted from TUP evaluation instrument (Garino, 2011). The questionnaire was modified based on the requirements of the study. The IT expert-respondents and environmentalists were requested to check his/her number of response mode to indicate his/her degree based on the indicators using a 5-point scale:

5- Excellent (E) – Indicated that the subject matter experts and IT professionals perceived the device full functionality is seems to be working perfectly.
4- Very Good (VG) – Indicated that the subject matter experts and IT professionals perceived the device functionality is seems to be working and met its requirements.
3- Good (G) – Indicated that the subject matter experts and IT professionals perceived the device functionality is seems to be working with minimal improvements to work on.
2- Fair (F) – Indicated that the subject matter experts and IT professionals perceived that some of device functionality is seems to be working with minimal improvements to work on.
1- Poor (P) – Indicated that the subject matter experts and IT professionals perceived that some of the device functionality is seems to be working and requires major improvements.

The rating was interpreted and describe based on their level of perception on the given indicators as the following: 4.20- 5.00 as Excellent, 3.40 – 4.19 as Very Good, 2.60 – 3.39 as Good, to some extend – 1.80 – 2.59 as Fair and 1.00 – 1.79 as Poor.

## RESULTS AND DISCUSSION

This section presents the software description that was used in the study, the software evaluation that was used in the assessment of the prototype and the overall results of the study. Figure 4 shows that when a tube filled with oil is placed onto the load cell, the data processing begins. The load cell sends the signal to the Hx711 amplifier that strengthens the signals to be more readable by the Arduino board. The Arduino board contains the coded formula for converting and computing the density of the oil in the container. For clarifications, the mass of the container has been deducted and is now equal to zero (0). The LCD screen displays the results in gram per cubic centimeter (g/cm3).

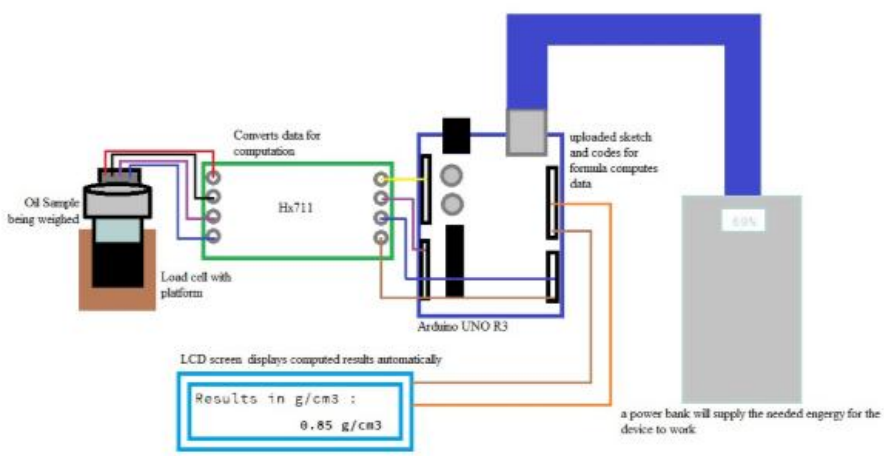


*Figure 4*. Structure and operation schematic of the digital oil density scale

Figure 5 shows how the prototype was supplied with power. A power bank was used to supply the power for the device to fully function. After the device is powered up, users can proceed to weigh oil samples. The LCDs show the results only if there is a sample placed on the load cell.

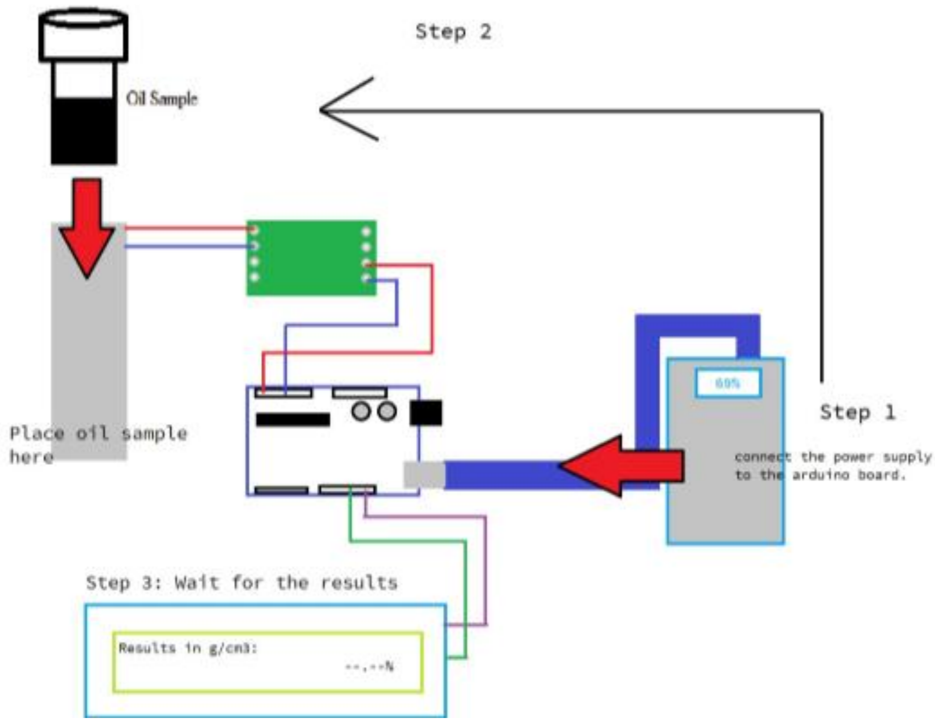


Figure 5. Shows the process of supplying power to the prototype and how it will function

Figure 6 shows the actual view of the oil density scale device. The device is powered by a power bank that supplies 2000mA for the device to function correctly. Three labels indicate the steps before using the digital oil density scale: (1) First step is to check the oil sample for water with the help of the liquid sensor, and (2) Second step is to proceed to the weighing of the oil sample for its density. The LCD screen will display the results in the unit of gram per cubic centimeter (g/cm3). (3) A hard copy can be produced by flipping a switch located at the right-hand side of the device generated by its built-in mini thermal printer.


Left View Top View Right View

*Figure* 6. Actual view of the oil density scale device

It could be gleaned from Table 2 that the functional acceptability of the hardware prototype obtained a composite mean score of 3.9042 with a verbal interpretation of very good from the perceptions of subject matter experts, while a composite mean score of 4.4633 with a verbal interpretation of excellent from the IT professionals was earned. An overall mean of 4.1837 with a verbal interpretation of very good from the two (2) groups of evaluators was obtained respectively.

The highest value of mean among indicators rated by the subject matter experts is evident by its ease of operation and its provision of comfort and convenience, while the lowest mean among the indicators rated by the subject matter experts is its competitiveness to price. The functional acceptability of the developed oil density scale device seems to provide convenience in handling and bringing it to the site where the oil spill is present due to its capability to allow the user to operate and understand the result provided by the device. Its practicality defines a new breadth for environmentalists and even other users who may use the device.

Table 2. Result summary of the developed prototype from the perceptions of IT professionals and environmentalists.

| Indicators | Subject Matter Experts (n=30) | | IT Professionals (n=30) | | Overall | |
|---|---|---|---|---|---|---|
| **Functionality** | | | | | | |
| Ease of Operation | 4.5000 | E | 4.4967 | E | 4.4983 | E |
| Provision of comfort and convenience | 4.5000 | E | 4.6667 | E | 4.5833 | E |
| User- Friendliness | 4.3333 | E | 4.7333 | E | 4.5333 | E |
| **Durability** | | | | | | |
| Quality of materials | 3.9333 | VG | 4.3333 | E | 4.1333 | VG |
| Quality of Workmanship | 3.8667 | VG | 4.3000 | E | 4.0833 | VG |
| Quality of design | 3.8333 | VG | 4.1667 | VG | 4.0000 | VG |
| **Economy** | | | | | | |
| Economy in terms of materials needed | 3.7333 | VG | 4.2333 | E | 3.9833 | VG |
| Economy in terms of time / labor spend | 3.8667 | VG | 4.5333 | E | 4.2000 | E |
| Economy in terms of machines required | 3.7667 | VG | 4.5000 | E | 4.1334 | E |
| The hardware peripherals are free of faults | 3.8000 | VG | 4.4667 | E | 4.1334 | VG |
| **Safety** | | | | | | |
| Absence of sparks from electricity | 3.8333 | VG | 4.7000 | E | 4.2667 | E |
| Absence of sharp edges | 3.9000 | VG | 4.6333 | E | 4.2667 | E |
| Provision for protection of device | 3.7000 | VG | 4.6044 | E | 4.1552 | VG |
| **Saleability** | | | | | | |
| Presence of market demand | 3.6333 | VG | 4.1667 | VG | 3.9000 | VG |
| Accessibility to finish product | 3.6667 | VG | 4.5000 | E | 4.0834 | VG |
| Competitiveness to price | 3.6000 | VG | 4.3778 | E | 3.9889 | VG |
| **Overall Mean** | 3.9042 | VG | 4.4633 | E | 4.1837 | VG |

*Scale: 4.20 - 5.00 Excellent, 3.40 - 4.19 Very Good, 2.60 - 3.39 Good, 1.80 - 2.59 Fair, 1.00 - 1.79 Poor*
*Legend: M - Mean, VI - Verbal Interpretation, E - Excellent, VG – Very Good, G- Good, F - Fair, P – Poor*

The device functionality is rated as excellent by two (2) groups of evaluators, subject matter experts and IT professionals. The quality of materials used, craft and design of the device seem to be constructed using materials that are strong enough to allow the device to function fully. Its overall rating obtained from the two groups of evaluators is very good. The economic viability of the oil density scale device is high, as compared to the bulky machines available in the market today. It can be observed in the numerical results in terms of economy obtained excellent evaluation on most items while on saleability where the device exhibits market opportunity when produced in large volume, the evaluators rated its overall saleability as very good. Finally, the oil density scale device is safe from electrical faults and sharp edges, thereby gives the overall convenience in handling the device. The device safety feature rated mostly of excellent by the two (2) groups of evaluators.

## CONCLUSION

The developed oil density scale device provided an alternative way of collecting the oil density samples in a handy, convenient and portable capabilities, thus have met all requirements in terms of all needed functions and characteristics. The device lessened the time and effort needed to transport oil samples to faraway laboratories with its compact size and portability. It can give results at the same time of testing of oil for its density. The device is useful and can be a great help to not only environmentally concerned citizens, but also it can teach other potential users to be aware of the dangers when oil is too dense. The digital device functions well in weighing oil density and in delivering its intended results.

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