Mobile app for calculating thermodynamic equations with Android Studio

Aplicación móvil para el cálculo de ecuaciones termodinámicas con Android Studio

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Key Handbooks

This work proposes the implementation of a mobile application for the calculation of thermodynamic equations that serves as a support tool for the learning process of students in the area; developed in Android Studio. The spiral methodological process was used that allows timely monitoring in each phase and, if it is necessary to restructure any phase, it allows it. Different topics are addressed such as temperature scale, laws of the corresponding states, ideal gas law, Van Der Waals law, gas density, among others. All of this is presented in an easy and agile way in an application that allows conversions from different scales if necessary and presents the results in the appropriate types, working with mid- and high-range devices without problem, as demonstrated in the results section.

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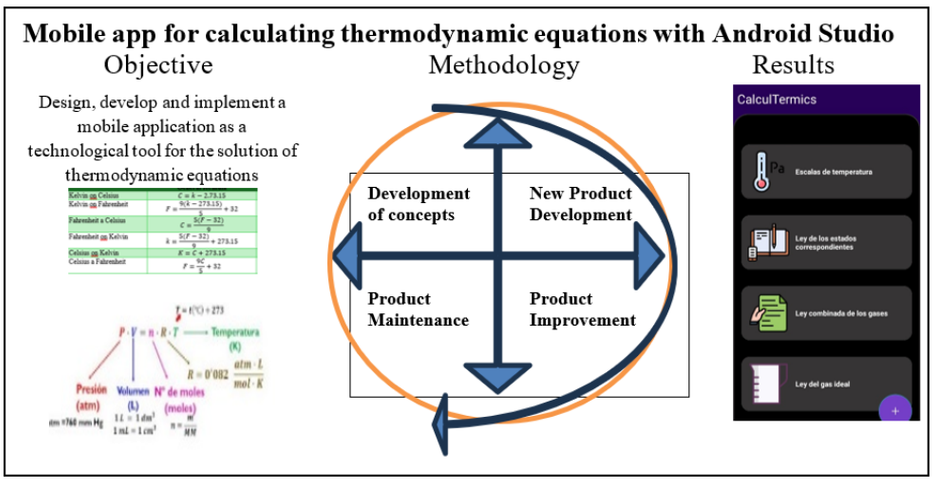
Handbook shelf URL: https://www.ecorfan.org/handbooks.php

Abstract

Mobile applications have acquired increasing importance and evolution in recent years, which brings with it the innovation of new strategies for education. The present work proposes the implementation of a mobile application for the calculation of thermodynamic equations that serves as a support tool for the learning process of chemistry students supporting in areas of matter and energy balance, physical chemistry, basic chemistry and thermodynamics; developed in Android Studio, as a feasible alternative for mobile learning to carry and integrate knowledge acquired by students inside and outside the school more easily. The launch of Android as a new platform for application development has caused great expectation and has been widely accepted by both users and the industry. It has now become the dominant alternative to other platforms (Tomás Gironés, 2019).

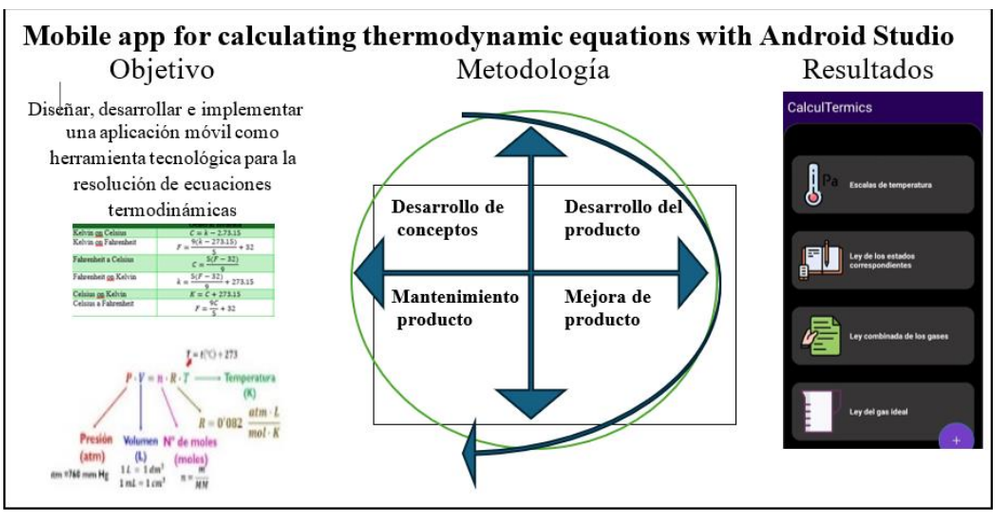


Keywords

Application, chemistry, thermodynamics, Android.

Resumen

Las aplicaciones móviles han adquirido una creciente importancia y evolución en los últimos años, lo que trae consigo la innovación de nuevas estrategias para la educación. El presente trabajo propone la implementación de una aplicación móvil para el cálculo de ecuaciones termodinámicas que sirva como herramienta de apoyo al proceso de aprendizaje de los estudiantes química apoyando en áreas de balance de materia y energía, fisicoquímica, química básica y termodinámica; desarrollado en Android Studio, como alternativa factible de aprendizaje móvil para llevar e integrar saberes adquiridos por los alumnos dentro y fuera de la escuela con mayor facilidad. El lanzamiento de Android como nueva plataforma para el desarrollo de aplicaciones ha causado una gran expectación y ha tenido gran aceptación tanto por parte de los usuarios como por parte de la industria. En la actualidad se ha convertido en la alternativa dominante frente a otras plataformas (Tomás Gironés, El gran libro de Android, 2019).



Aplicación, Química, Termodinámica, Android

Introduction

A mobile application is an application designed to run on mobile devices (Smartphone, Tablet, etc.) and is usually available through distribution platforms, operated by the companies that own the mobile operating systems such as Google's PlayStore for Android, Apple's APPStore for iOS, BlackBerry OS, Microsoft's WindowsStore for Windows Phone, among others. There are free mobile applications and others for a fee; they can be differentiated as: Native is one that is programmed to be installed within a given operating system. Programmed under the language or Framework recommended by the operating system manufacturer. Web: This type of application is accessed through the Web or an Intranet network.

To access them, the essential requirement is to have a web browser that allows you to run them. A webApp can be categorized as a computer program, with the difference that it is executed from a web browser. Its structure is mostly made up of: HTML, CSS, JavaScript, and/or some other programming language that works on the server side (PHP, ASP.net, Python, Ruby, CGI, Perl, etc.).

Hybrid: Web application developed with HTML, CSS and JavaScript standards, among others, which is packaged under a set of rules and parameters that allows it to be installed on a device like any native application. Then, when executed, the hybrid application will use the web browser engine, hiding its menu, its address bar and tools in order to disguise that the WebApp is a native application. (Luna, Desarrollo web para dispositivos móviles: Herramientas para diseñar y programar WebApps, 2022)

Android is an operating system, initially designed for mobile phones such as iOS (Apple), FireFoxOS (Mozilla) and Blackberry OS systems. Currently this operating system is installed not only on mobile phones, but also on multiple devices, such as tablets, GPS, televisions, multimedia hard drives, mini computers, etc. It has even been installed in microwaves and washing machines. It is based on Linux, which is a free, free, cross-platform operating system kernel. This operating system allows applications to be programmed using a variation of Java called Dalvik (or ART from Android version 5.0 onwards) and provides all the necessary interfaces to easily develop applications that access the phone's functions (such as GPS, calls, phonebook, etc.) using the Java programming language. The use of technologies allows for the efficient sharing of resources and at the same time that citizens are always updated and informed, applications play an important role in the daily lives of people who can be connected at any time from anywhere else, such is the case of this work that allowed access requests to be tracked. monitoring and notifications in a timely manner, it was also possible to update the data of the dependencies, assign those responsible and manage, among some other benefits that the application yielded(RAFAEL-PÉREZ, 2020). The Figure 1. Android Architecture shows the overall structure of Android. As you can see, it is made up of four layers. One of the most important features is that all layers are based on free software. (Tomás Gironés, El gran libro de Android, 2019).

Box 1

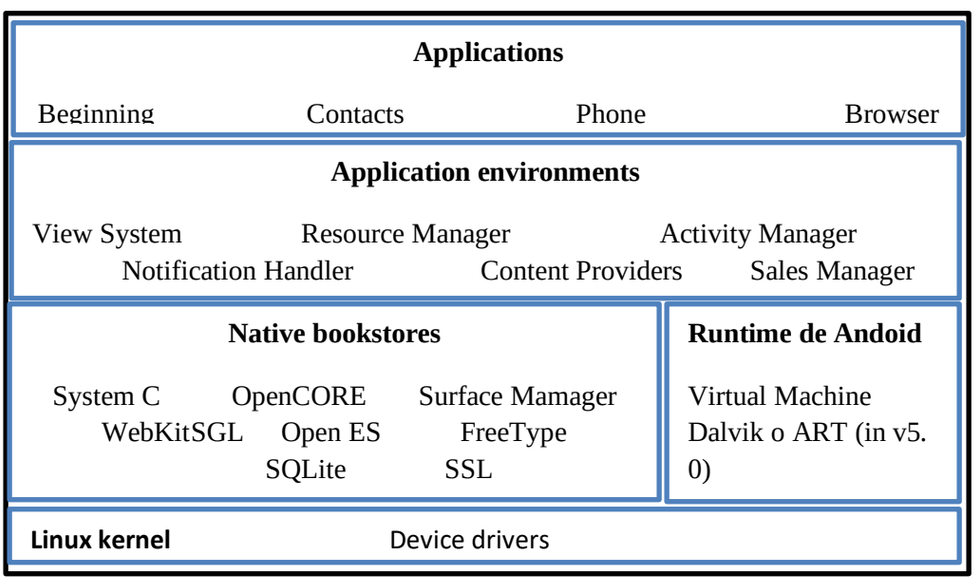


Figure 1

Android architecture

(U.P.d.V., 2017)

It includes a set of C/C++ libraries used in various Android components. They are compiled in open source. Some of these bookstores are:

- **System C library:** A derivation of the standard C BSD library (libc), adapted for Linux-based embedded devices.
- **Media Framework:** PacketVideo's OpenCORE-based library. It supports playback and recording codecs of a multitude of audio and video formats and MPEG4, H.264, MP3, AAC, AMR, JPG and PNG images.
- **Surface Manager:** Handles access to the 2D and 3D graphics subsystem.
- **WebKit/Chromium: Supports** the web browser used on Android and in WebView view. In version 4.4, WebKit has been replaced by Chromium/Blink, which is the basis of Google's Chrome browser.
- **SGL:** 2D graphics engine.
- **3D libraries:** Implementation based on OpenGL ES 1.0 API, libraries use the 3D hardware accelerator if available, or the highly optimized 3D projection software.
- **FreeType:** *bitmap* fonts and vector rendering.
- **SQLite:** Powerful and lightweight relational database engine available for all applications.
- **SSL: Provides** Secure Socket Layer *encryption services* .

Different projects have been studiedlSides for Android for example a project for a Academic body, which I use Software Engineering Methodologies, It is connected to a comprehensive school control system implemented in the institution, where your objective was orOrder and consult academic information (Vega-Olvera, 2018) . On the other hand, there is The project that helps reduce energy consumption in hotels through an indicator that warns if any Electrical device is active, In order to be able to deactivate them before departure, the main objective of this project is to Reduce energy consumption and contribute caring for the environment and as a plus to pay high bills for this input (Rojas-Nando, 2019).

Working architecture

The spiral development model is a combination of the Waterfall model and an iteration model. The process goes through different stages, from conceptualization, following development, then an improvement phase to finish with maintenance.(Roche, 2020). The diagram is exposed to reverting to some process if necessary during the development of the mobile application. Step 3 will skip the risk analysis process. The proposed methodology for the development of the mobile application is shown in Figure 2.

Box 2

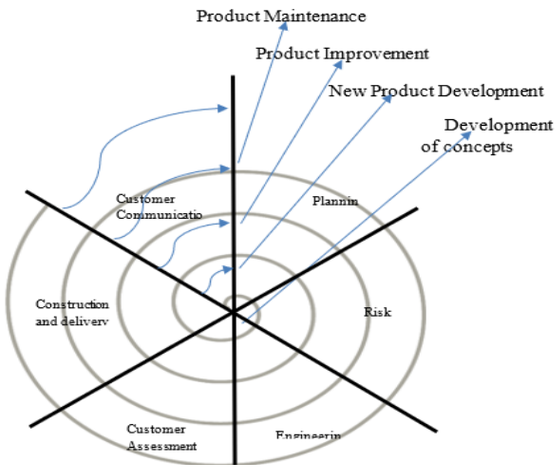


Figure 2

Spiral methodology

Source: Own work

2.1 Communication with the customer

The difficulties presented by students to clear equations in the field of thermodynamics were identified, prioritizing those of greater complexity to delimit the scope that the application will have. Based on the information obtained, a series of requirements were established that the application must satisfy:

- The application must support teaching, be attractive and understandable for the user.
- The app must be available for the Android system.
- The application must reinforce the most important and most difficult topics for students, as well as didactic support for the teacher.
- The application must allow you to arrive at a result from different solutions for each exercise.
- The application must be well validated so that it yields 100% acceptable results with no margin for error.
- The application must contain a glossary with the main concepts regarding the topic of thermodynamics.
-

Box 3

Table 1

Form details each of the proposed laws and their respective clearances

Laws		General formula	Clearances	
Temperature scale	Kelvin on Celsius	$C = k - 2.73.15$		
	Kelvin on Fahrenheit	$F = \frac{9(k - 273.15)}{5} + 32$		
	Fahrenheit a Celsius	$C = \frac{5(F - 32)}{9}$		
	Fahrenheit on Kelvin	$k = \frac{5(F - 32)}{9} + 273.15$		
	Celsius on Kelvin	$K = C + 273.15$		
	Celsius a Fahrenheit	$F = \frac{9C}{5} + 32$		
Law of the corresponding states	Avogadro's Law	$\frac{V_1}{n_1} = \frac{V_2}{n_2}$	$n_1 = \frac{n_2 v_1}{V_2}$	$v_1 = \frac{n_1 v_2}{n_2}$
			$n_2 = \frac{n_1 v_2}{v_1}$	$v_2 = \frac{n_2 v_1}{n_1}$
	Boyle's Law	$P_1 V_1 = P_2 V_2$	$P_1 = \frac{P_2 V_2}{V_1}$	$V_1 = \frac{P_2 V_2}{P_1}$
			$P_2 = \frac{P_1 V_1}{V_2}$	$V_2 = \frac{P_1 V_1}{P_2}$
	Charles' Law	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$T_1 = \frac{T_2 V_1}{V_2}$	$V_1 = \frac{T_1 V_2}{T_2}$
			$T_2 = \frac{T_1 V_2}{V_1}$	$V_2 = \frac{T_2 V_1}{T_1}$
Law of the corresponding states	Ley de Gay-Lussac	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	$T_1 = \frac{T_2 P_1}{P_2}$	$P_1 = \frac{T_2 P_1}{T_1}$
			$T_2 = \frac{T_1 P_2}{T_2}$	$P_2 = \frac{T_2 P_1}{T_1}$
Combined Gas Law		$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$	$V_1 = \frac{V_2 P_2 T_1}{P_1 T_2}$	$P_1 = \frac{V_2 P_2 T_2}{V_2 T_1}$
			$V_2 = \frac{V_1 P_1 T_2}{P_2 T_1}$	$P_2 = \frac{V_1 P_1 T_2}{V_2 T_1}$
			$T_1 = \frac{V_1 P_1 T_2}{V_2 P_2}$	$T_2 = \frac{V_2 P_2 T_1}{V_1 P_1}$
Ideal Gas Law		$PV = nRT$	$P = \frac{nRT}{V}$	$T = \frac{PV}{nR}$
			$V = \frac{nRT}{P}$	$\sqsubset\sqsupset = \frac{p}{RT}$
			$n = \frac{PV}{RT}$	
Density of a gas		$d = \frac{PPM}{RT}$		
Real Gas		$PV = ZnRT$	$Z = \frac{PV}{nRT}$	
Ecuación de Van Der Waals		$\left(p + \frac{a\,n^2}{v^2}\right)(v - nb) = nRT$		

2.2. Planning

It focuses on planning on basic concepts of the project, defining the scope of the project and establishing it with the functionalities where it is to be reached. The requirements of the students for which the application is to be developed are analyzed. Within this phase they perform three tasks:

- Identification of user requirements: Know the problems or needs that are intended to be solved with mobile technologies and characteristics that the application must have.
- Identification of hardware requirements: For the development of applications in the Android operating system, it is necessary to meet a series of requirements at least so that the computer can support and/or execute an application.
- Weekly meetings for the correction of the logic to perform mathematical calculations, dispel doubts and test the operation of the application.

Box 4

Table 2

Hardware Requirements

Requirements	Capacity
Intel Core i3 processor	3 to 3.5 Ghz
RAM	8 GB
Screen Resolution	1280 x 800 pixeles
Emulation support	VT-x or similar (virtualization)

Source: Own work

Box 5

Table 3

Software Requirements

Requirements	Capacity
Operating system	Windows 10 de 64 bit
Java Development Kit (JDJK)	8
Android Studio	2021.1.1.1 Patch 2 o superior
Android0 Emulator	Optional

Source: Own work

Requirements and complementary features

- The application will only be developed for the Android platform.
- System developed under the Java platform.
- It will allow access to users without the need to log in.
- The average response time of the application should not exceed 10 seconds.
- The app will be available all the time as it is a native and free app.
- The application must be compatible with versions and later than the Android operating system.
- The system features the Controller View Model, the design pattern is layered, making it easy to maintain the system.

2.3. Engineering

The coding of the application in Android Studio will be done in the Java programming language. In addition to this, the functional tests to verify each formula of the application in different scenarios and conditions, for this the following tasks are performed:

Emulation and simulation: tests are carried out simulating and emulating the mobile device, exploring all the utilities and functions of the application by entering different data, including erroneous data to measure the functionality and level of robustness of the software. If faults are found, you should return to the "programming" stage to troubleshoot the issues.

Real devices: The application is installed on real computers with Android operating system.

According to the client's guidelines and requirements, the following flow charts are proposed as a support tool to program the phases and logical activities of the application. Figure 3. Overview Flowchart expresses the main activities that the user will see when opening the application. Inside them, there will be a splash screen that will give way to the main screen where the user will access the main menu. The user can then select any of these options (Temperature scales, law of the corresponding states, combined law of gases, ideal gas law, density of a gas, real gas law and Van Der Waals equation). An alternative side navigation menu will be considered with the options of: information about and share app.

Box 6

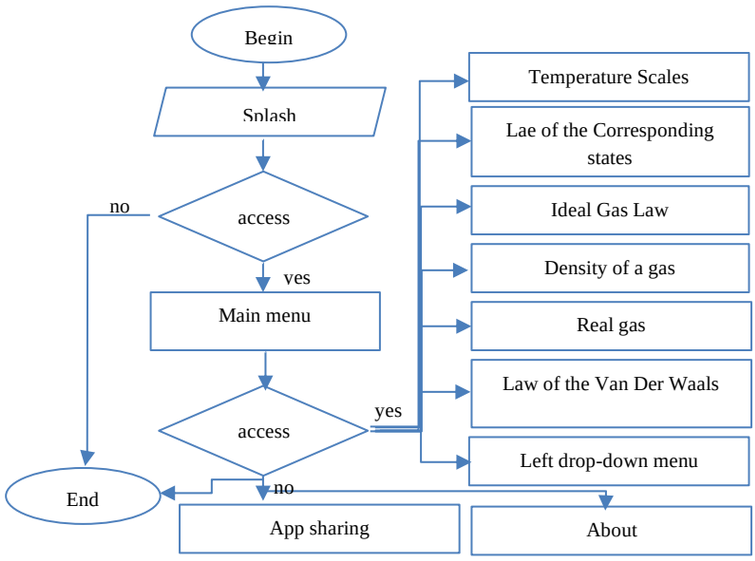


Figure 3

General Flowchart

Source: Own work

Figure 4. Flowchart of "Temperature Scales" exposes the logical operation, the user will see the main menu, selecting "Temperature Scales" will take you to the following screen, there you will find six temperature conversions: Kelvin to Celsius, Kelvin to Fahrenheit, Fahrenheit to Celsius, Fahrenheit to Kelvin, Celsius to Kelvin and Celsius to Fahrenheit, if you do not want to perform any of them, Return to the main menu or you can exit the app.

Box 7

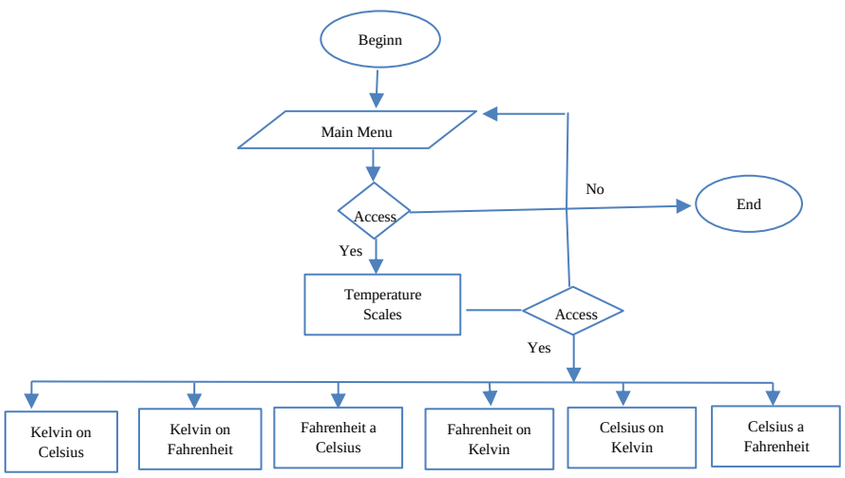


Figure 4

"Temperature Scales" Flowchart

Source: Own work

Figure 5. Flowchart "Combined Law of Ideal Gases". It shows a series of steps that the user will follow to obtain the values of the combined law of gases that determines that pressure is inversely proportional to volume and directly proportional to temperature; is a compilation of the laws mentioned above (Avogadro, Boyle, Charles and Gay-Lussac Law).

Box 8

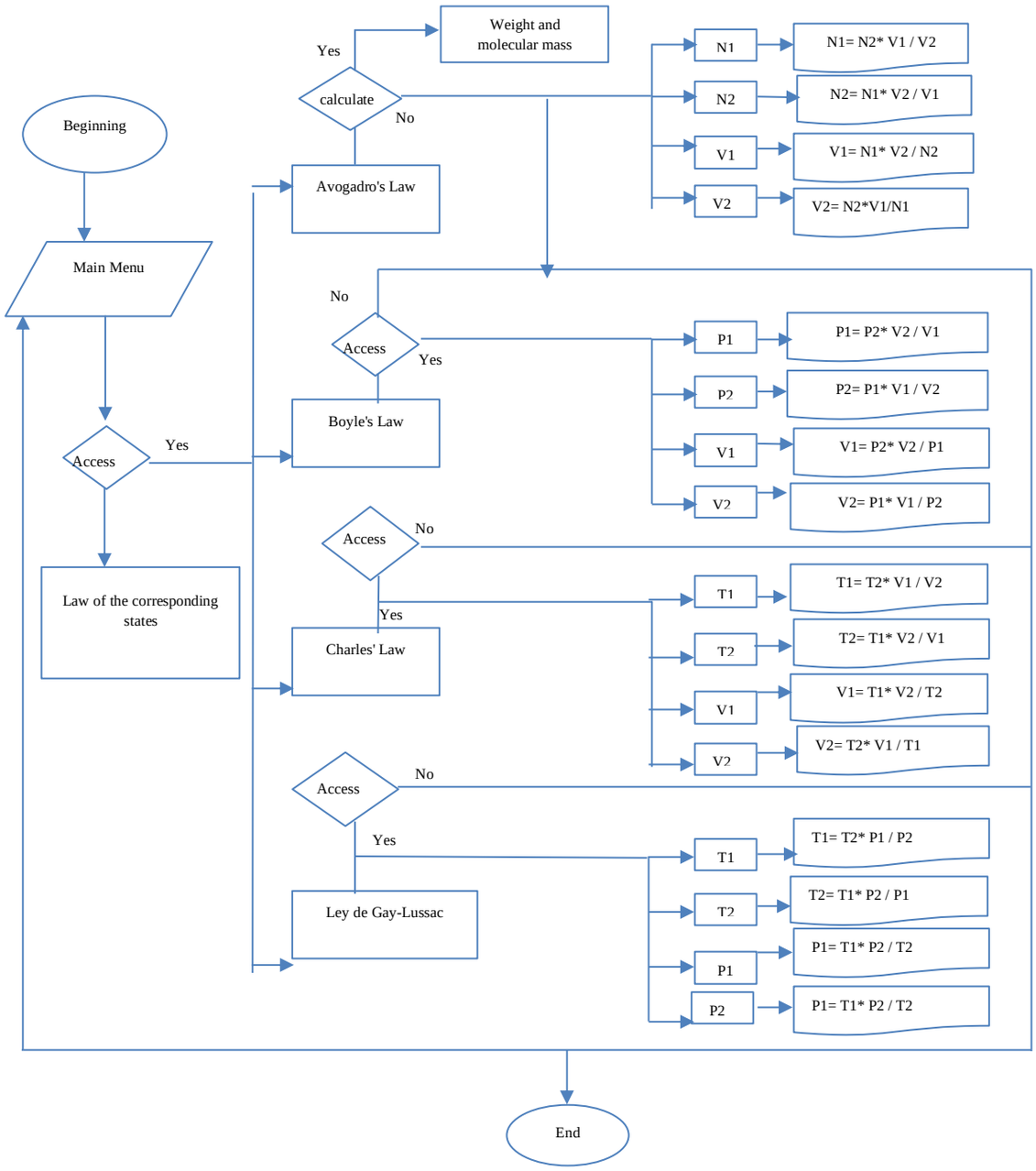


Figure 5

Flowchart "Combined Law of Ideal Gases"

Source: Own work

The section "Combined Law of Ideal Gases" works similar to the previous diagram and would show a series of steps that the user will follow to obtain the values of the combined law of gases that determines that pressure is inversely proportional to volume and directly proportional to temperature; it is a compilation of the laws mentioned above (Avogadro's Law, Boyle, Charles and Gay-Lussac).

With regard to the "Ideal Gas Law", a screen will be displayed with a submenu with five options to calculate: volume, mole number, temperature and concentration. The process to perform any of the calculations is considered the values of R, it is a constant that can vary according to the exercises established by the teacher. The possible conversions to the units of measurement established by the constant R will be defined in detail. The user can decide whether they want to perform some calculations, return to the main menu, or exit the application, similar to the diagram in Figure 5.

Consequently, the formula for calculating the density of a gas is determined with a general equation, which will allow the user to visualize it immediately after selecting that option. The data of the constant R will also be used, such as the validation of the units of measurement indicated. See Figure 6. Flow diagram "Density of a gas".

Box 9

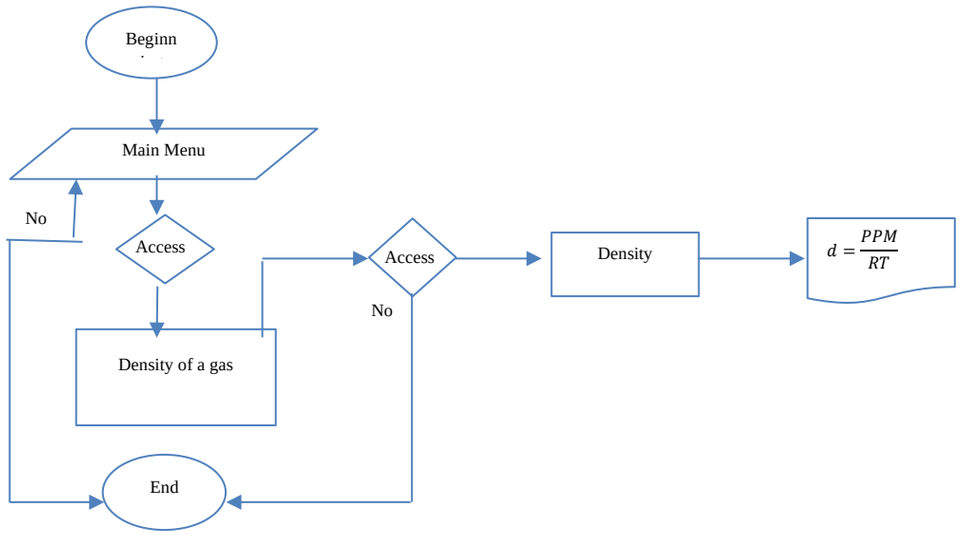


Figure 6

Flow diagram "Density of a gas".

Source: Own work

On the main menu screen there is the alternative to calculate the real gas from the general formula, the application will be limited so that it performs only the calculation of the comprehensibility factor without clearing the other variables.

The user will carry out some other process, either before or after, for the solution of the exercise proposed by the teacher. Similar to the diagram in Figure 5. Just as the Van Der Waals equation is a complex equation, it will also be delimited, the user will only visualize the general equation to solve the exercises; They will carry out the conversions, substitutions or clearances (first degree, second degree, general formula) according to the request posed by the problem.

The main activity of the application, shows the use of an ArrayList that allows you to add, delete and modify the listed elements dynamically from RecyclerView and together with GridLayoutManager() that places elements in a two-dimensional grid vertically, makes all of them have the same width and height. The user will see the seven menu options on the Main Screen.

Discussion

The following images, figure 8, show the app installed on different Android versions and screen resolution. starting with Android version 12 and 25, also Android 9 respectively, it is appreciated that the application works correctly, the elements are molded according to the resolution of the screen.

Unlike the Android 13 version, all elements are responsive but the brand of the OPPO phone does not allow the functionality of justifying texts, so in the descriptions of the law of the corresponding states they differ a little in the left and right margins. Some phones may differ in changes to some parts of the app depending on the settings of each phone model.

Box 10

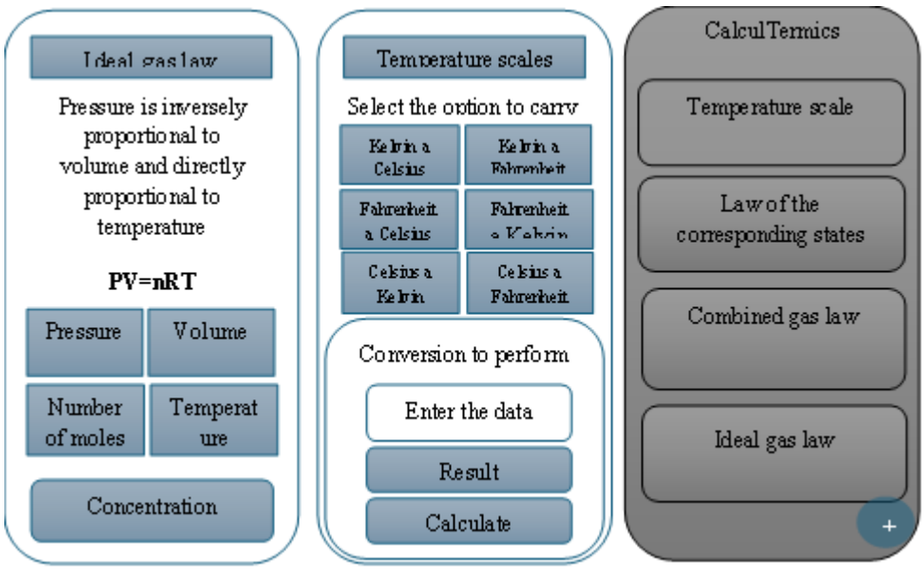


Figure 7

Version and architecture

Source: Own work

Time Trials

The implementation of the developed mobile application helped not only new students but also students of advanced semesters to perform calculations of laws on thermodynamics. The estimated time given to chemical engineering students to solve different exercises is around 15 to 20 minutes depending on the conversions or laws that they have to apply for each of them. A physical test was done with the seventh-semester group of 20 students and they did the exercises first without application, then with it to measure the time it takes to solve them in both processes.

The following graph shows the results obtained in these tests, it is observed that it is reduced to 80% of the time, figure 9.

Box 11

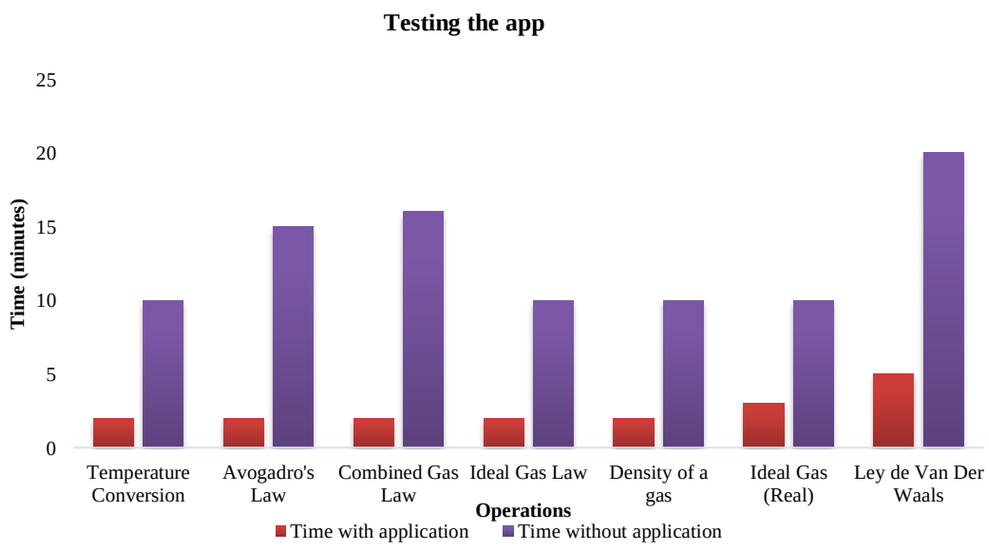


Figure 8

Test Chart

Source: Own work

Table 4. Mobile devices a list where the application was installed is displayed, in none of them did it present operating and installation errors.

Box 12

Table 4

Mobile devices

Telephone	Android Operating System
Samsung 6	10
Hawei	9
Motorola	9
Oppo reno 7	13
LG 0	10
XLAOMI	12
Oppo 5	12

Source: Own work

Conclusions

The CalculTermics mobile application is an important innovation in the area of engineering; it will be of great pedagogical help both for teachers of the Chemical Engineering career and other technological careers that address subjects related to the subject of thermodynamics.

The project carried out responds to the expectations and requirements that were specified in the objectives and hypotheses. After carrying out the test with different exercises using the application, the results obtained showed that the solution of each of them was reduced by 80%. When solving each exercise without the app, the students took about 15 to 20 minutes depending on the complexity. The usefulness of this tool to reinforce and enrich new forms of learning adapted to technological progress was confirmed, allowing both the student and the teacher to facilitate learning in a dynamic, simple, attractive way and save time in the solution of the laws of thermodynamics. The students did not present difficulties in downloading and installing the application on different devices with Android operating system.

It should be noted that CalculTermics has some issues that need to be improved for optimal performance. However, it is the first application that focuses on solving thermodynamics laws with calculator functionality. There are other applications that only handle information or conversions, but none perform a mathematical calculation with their clearances.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no financial interests or personal relationships that could have influenced this book.

Authors' contributions

Bartolo-Mendoza, Diana Y: Contributed to the idea, development, and testing of the app.

López-González, Erika: Contributed research method, technique and the writing of the research article

Reyes-Nava, Adriana: Contributed to the revision of the research method and technique.

Availability of data and materials

Indicate the availability of the data obtained in this research.

Funding

Indicate whether the research received any type of funding.

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Abreviaturas

ASP.net	marco web de código abierto, creado por Microsoft
CGI	Computer-generated imagery
CSS	Cascading Style Sheets
GPS	Global Positioning System
HTML	HyperText Markup Language
iOS	Apple's mobile operating system
OS	operating system
Perl	Cross-platform scripting programming language
PHP	Hypertext Preprocessor

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