An-Najah National University

Faculty of Engineering & information technology

Computer Engineering department

Presented in partial fulfillment of the requirements for Bachelor degree in Computer Engineering

Graduation project 1

CircuitAcademy

Web platform and mobile application

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Acknowledgement:

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We can't forget to acknowledge and thank everyone who contributed their time, effort, insight, and assistance during the preparation of this project. And we hope this work shows the knowledge and effort invested throughout the development of this graduation project.

Disclaimer:

This report was written by students Ghassan Qasrawi and Adel Qadi at the Computer Engineering Department, Faculty of Engineering and Information Technology, An-Najah National University. It has not been altered or corrected, other than editorial corrections, as a result of assessment, it may contain language as well as content errors. The views expressed in it together with any outcomes and recommendations are solely those of the students. An-Najah National University accepts no responsibility or liability for the consequences of this report being used for a purpose other than the purpose for which it was commissioned.

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Abstract:

The Goal of this project is to implement a cross-platform learning platform that helps students better understand circuit and electronics topics such as DC and AC analysis, circuit design, and simulation. We noticed that many students in electrical and computer engineering departments struggle to bridge the gap between theoretical concepts and practical application in circuits courses. This platform addresses that gap by combining interactive learning resources with collaborative tools and a web-based circuit simulator, making electronics education more accessible and engaging.

The significance of this project lies in its focused support for electronics learners. Unlike general e-learning platforms, this system is designed specifically to help users visualize, simulate, and discuss electronics-related problems in real time. It empowers students to learn independently or collaboratively, practice simulations directly in their browser, and reinforce complex topics through live sessions and community discussion.

Key aspects covered in this project include course content centered on electronics and circuit analysis. Community groups and messaging features for peer support. Real-time video meetings for instructor-led sessions. A fully integrated NGSpice-based simulator for hands-on circuit testing with the explanation of analyzing different circuits. And accessibility via both web and mobile platforms.

The main objectives of the project are to provide a user-friendly, interactive platform tailored to circuits and electronics education. Integrate practical simulation capabilities to complement theoretical learning along with a detailed explanation on how to solve different circuits. Foster a collaborative environment through course-based communities, peer-to-peer messaging, and live meetings. Also deliver consistent learning experience across devices.

The platform was developed using Flutter for both web and mobile frontends, enabling cross-platform deployment with a shared codebase. The backend is built with Node.js, and Firebase powers real-time messaging and notifications. Other APIs were used to ensure efficient media and files handling like “Cloudinary” and “SupaBase”.

While various learning platforms and online course tools exist, few focus on electronics and circuit simulation in an integrated way. Also, software programs like Multisim or Proteus require installation and lack social or course-based features. By combining simulation, community, and learning management in one platform, this project fills a unique niche and offers a more complete, hands-on learning experience for electronics and circuits students.

Chapter 1: Introduction

1.1 General background

Many students struggle with studying circuit and electronics courses and understanding the basics of DC and AC analysis especially when relying solely on traditional teaching methods which lack the interactive part required for the nature of these concepts and topics. They also fall short in providing suitable clarity and interaction for deep understanding for such complex concepts. This can lead to multiple gaps in fundamental knowledge and lower academic performance in electrical and electronic engineering courses and circuits related subjects.

Thus, we address this issue by using an easy to use, interactive and efficient platform that different users can use to learn and apply their knowledge using the developed simulator.

1.2 Objectives

This project aims to help students who struggle in circuits and electronic concepts and topics to understand them in an interactive way by using a web-based simulator that enables them to design their own circuits and simulate them on demand, strengthen their knowledge in fundamental topics by enabling users to create and publish courses between them which each one of them is connected to a community to make it easy to connect and reach each other.

1.3 Organization of the report

The report's organization aims to give readers a thorough grasp of CircutAcademy web-platform and Mobile app. Chapter 2 explores the theoretical Background and previous studies after this introduction, laying the foundation for this project. The platform's development process is described in Chapter 3. In Chapter 4, discussion and results are presented, providing an understanding of the project's results. In Chapter 5, recommendations and conclusions are combined to give a comprehensive summary of the project's journey.

Chapter 2: Theoretical background and literature review

2.1 Theoretical background

2.1.1 Circuits Online learning platform

Online learning platforms are designed to deliver suitable and comprehensive flexible access for students to a variety of instructional content, exercises and most importantly, interactive tools tailored to student needs. For circuits and electronics topics, these platforms promote active and self-directed learning which lets learners interact with the content at their own pace and engage with concepts like circuit analysis and behavior. Some examples of these interactive tools might be live meeting sessions, examples or quizzes, simulations, and so on which makes a specific platform stand out more than others.

2.1.2 Simulation in online education

Interactive learning is the key to successful online learning, especially in electronic and circuits related topics. Circuit simulators offer suitable virtual hand-on experience that assists learners deepen their knowledge in electric studies by checking results instantly which improves learning and engagement. Therefore, we implemented a web-based simulator in our project.

2.1.3 Mobile learning

With the increasing reliance on smartphones and tablets, mobile learning has become a vital tool for online education, especially for circuits and electronic related topics. It allows learners to access courses content and simulations anywhere anytime supporting flexible sustainable learning operation. Thus, we included a mobile application in our project.

2.1.4 Importance of a good UI and UX Design

For both a web platform and a mobile application, an intuitive user interface and user experience are crucial for effective learning exceptionally for technical subjects like circuits and electronics. A well-designed interface gives a powerful experience to the user and allows easy navigation between multiple screens, which is very important when dealing with circuit diagrams. So, we made sure the UI & UX are efficient and user-friendly for our project.

2.2 Literature review

This section delves into key themes pertinent to the development and implementation of CircuitAcademy counting online active learning and education, mobile learning, simulation tools importance in interactive learning and web-based platforms. These fields supply students and learners in general with perception of effective practices and technologies that strengthen interactive and easy to access circuits related and electronics education.

2.2.1 Active learning in online circuits related and electronics education

Research emphasizes the strong potential of active and empirical learning in developing awareness of electronics and circuit related subjects. Active learning methods - such as virtual labs, hands on exercises, and learner-generated content - have been shown to significantly improve motivation, engagement and knowledge retention in online electronic courses.[1]

2.2.2 Mobile learning for electronics

Studies on mobile learning for circuits and electronics education demonstrate that smartphone-based platforms - like mobiles and tablets – can enhance commitment and knowledge retention. Mobile learning that delivers interactive learning via smartphones has shown to improve flexibility, engagement, and accessibility in electronics education. A recent case study demonstrated that mobile applications supporting electronics and sensor learning effectively enhanced students' motivation, knowledge retention, and learning outcomes, while equally highlighting challenges such as device compatibility and interface usability.[2]

2.2.3 Simulation-based learning & self-efficacy

Learning through simulation has been shown to improve students' performance and confidence in circuit analysis. During the COVID-19 pandemic, a study looked at the effects of computer-based circuit simulation on students' performance and confidence in courses on electric circuit analysis. The findings demonstrated notable increases in self-efficacy and perceived learning gains, underscoring the usefulness of simulation in situations where access to hands-on labs is limited.[3]

2.2.4 Design principles in learning platforms

A well-designed learning platform portrays a crucial aspect in supporting electronics and circuits related education through diminishing aberration and enhancing learner focus. Clean layout and intuitive navigation are keys in helping learners stay focused and engage in circuit simulations. Following these principles ensures better usability and reduced cognitive load which permits good interaction and understanding. Using accepted usability guidelines results in more effective and fulfilling educational experiences.[4]

While simulations and active learning have extraordinary benefits, many existing platforms and solutions stay isolated focusing either on mobile delivery or simulation alone. Therefore, comes a need for a unified podium that merges well-designed and structured electronic content, interactive simulation, mobile application and web access in one environment that we ensured CircuitAcademy delivers.

Chapter 3: Methodology

This chapter dives into the details of the approach we followed to design, develop and implement our solution to the previously explained problem by discussing the work we have done to hand the final value to multiple stakeholders that will benefit from this project who are: circuits and electric courses students and learners, electrical topics lecturers and teachers, and anyone who wants to learn about circuits. Moreover, an overall overview of utilities, tools and detailed description about interfaces used to develop both the web platform and the mobile application are provided in this research.

3.1 Specifications & Standards

We selected a set of robust, effective, and professional tools and utilities during the development of CircuitAcademy, we also utilized different frameworks along with other APIs and combined them to ensure full scalability and efficiency, the following highlights what we used in implementing CircuitAcademy:

1. **Programming languages and frameworks:** For the front-end development, we used **Flutter** for both web and mobile enabling easy cross-platform development from same code base and ensuring unified user experience. Also providing us with many helpful and scalable packages for both web platform and mobile application.

2. **Back-end infrastructure: Node.js** along with **Firebase** for real-time messaging and notifications, as well as **python** to access **sympy** library for generating explanations for the simulation.

3. **Database choice: Mongodb** which enabled easy data handling with NOSQL JSON documents**.**

4. **Used APIs and technologies:** We used different APIs and technologies to help us provide the best experience and functionality for dealing with assets, file handling, live meetings and the simulator during building CircuitAcademy which are:
    - **Cloudinary:** Cloud storage platform, used for managing, uploading and delivering images, lectures and different assets used in the project.
    - **SupaBase:** Free Firebase alternative that provides multiple free solutions for database and storage, used for handling courses files and examples management.
    - **VideoSDK:** Real-time voice and video infrastructure, used for live meeting sessions.
    - **NgSpice:** Official open-source SPICE circuit simulator, used in developing the simulator for the platform.
    - **GnuPlot:** Portable command-line driven graphing utility, used for oscilloscope implementation and plotting in the simulator.

3.2 User interface overview

3.3.1 Web platform

- **Home page**: The introductory page of CircuitAcademy website which presents the platform for users and core features used in it, the following figures show the content of the home page.

Figure 1: Home page

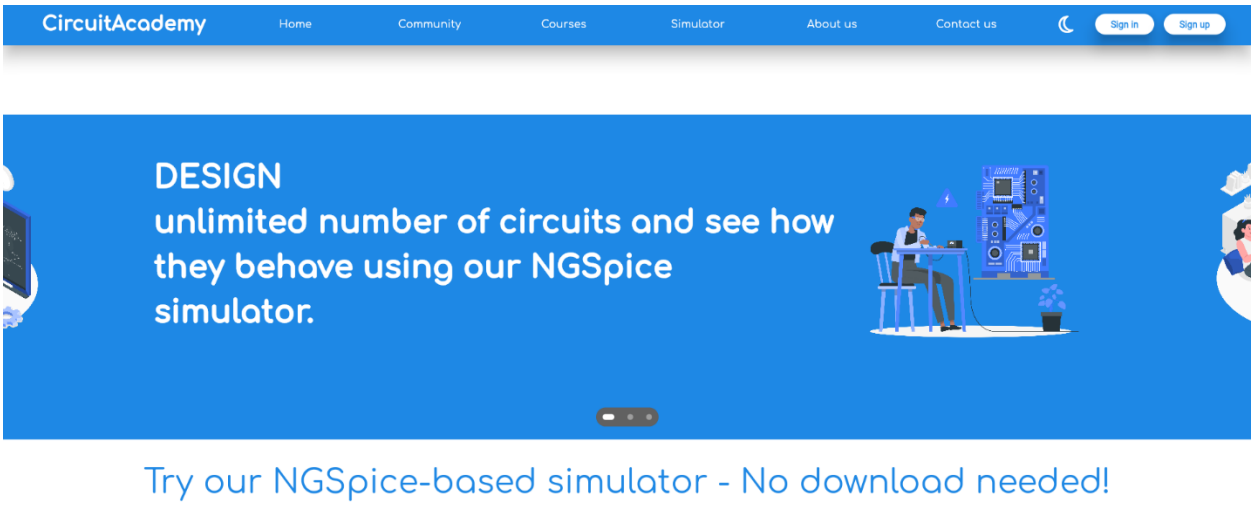


Figure 2: Slider – Design

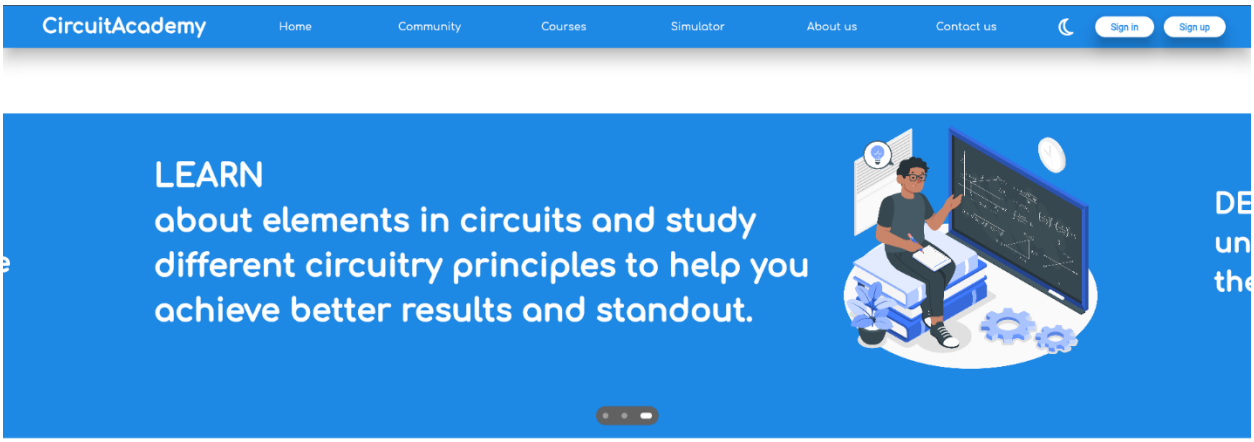


Figure 4: Slider - Learn

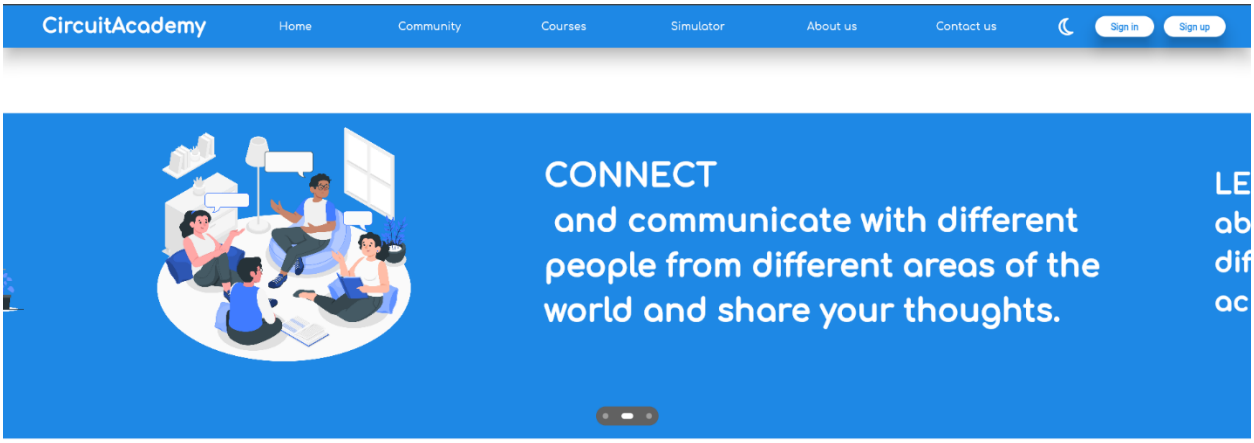


Figure 3: Slider – Connect

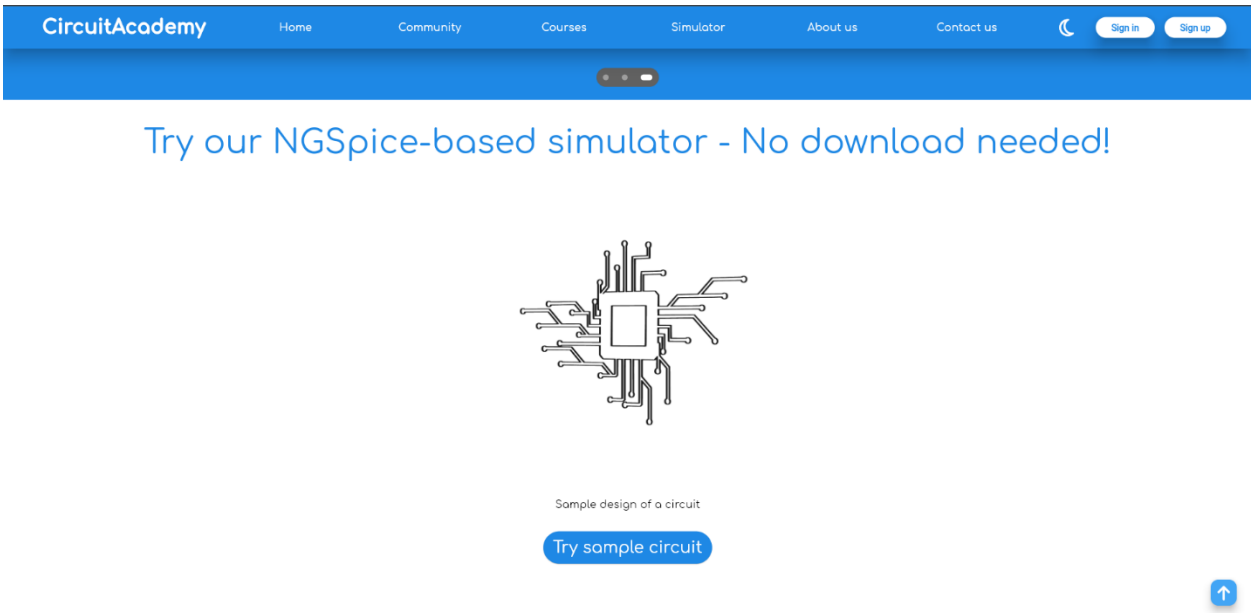


Figure 5: Simulator section

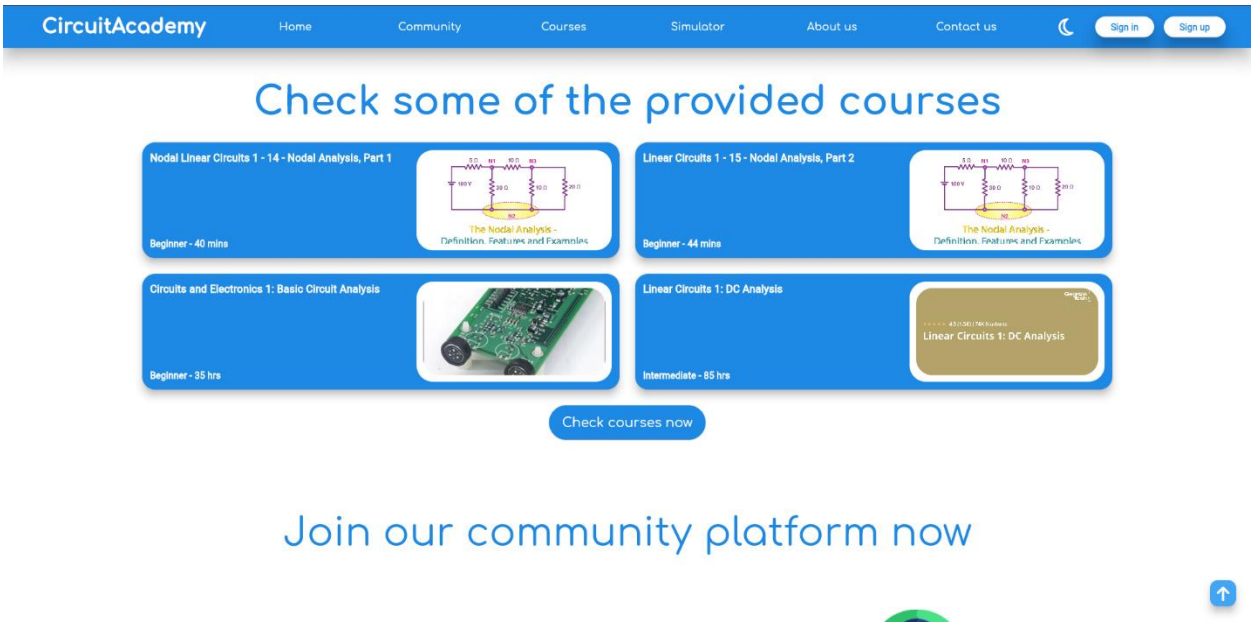


Figure 6: Sample courses section

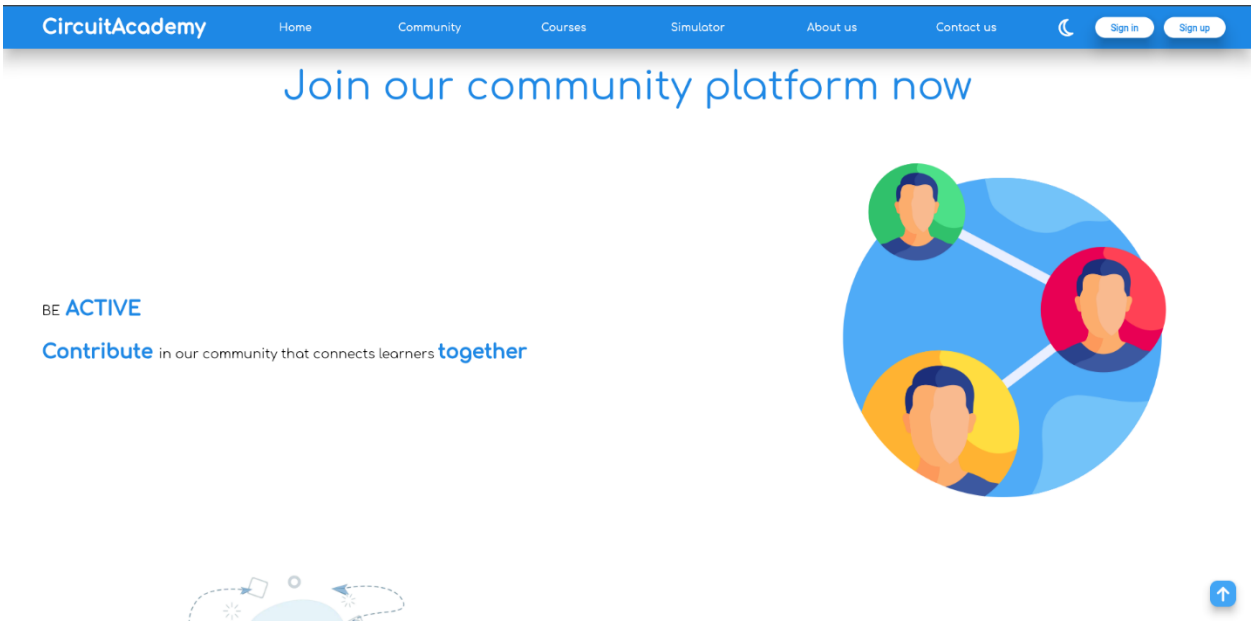


Figure 7: Community section – connect

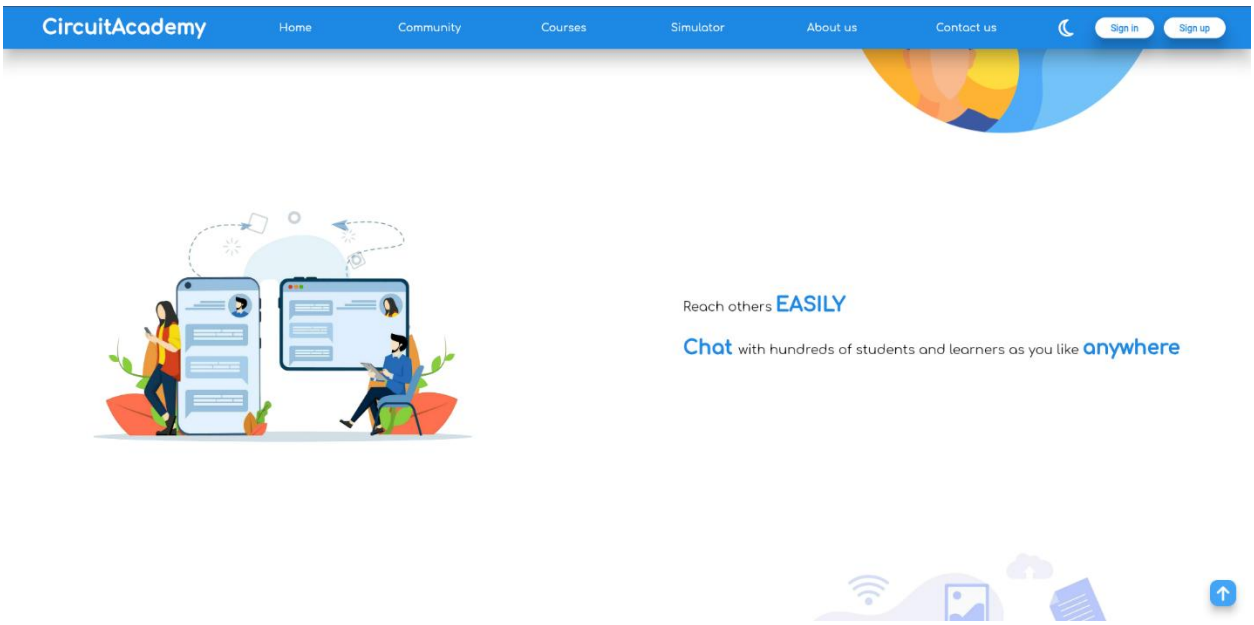


Figure 8: Community section - chat

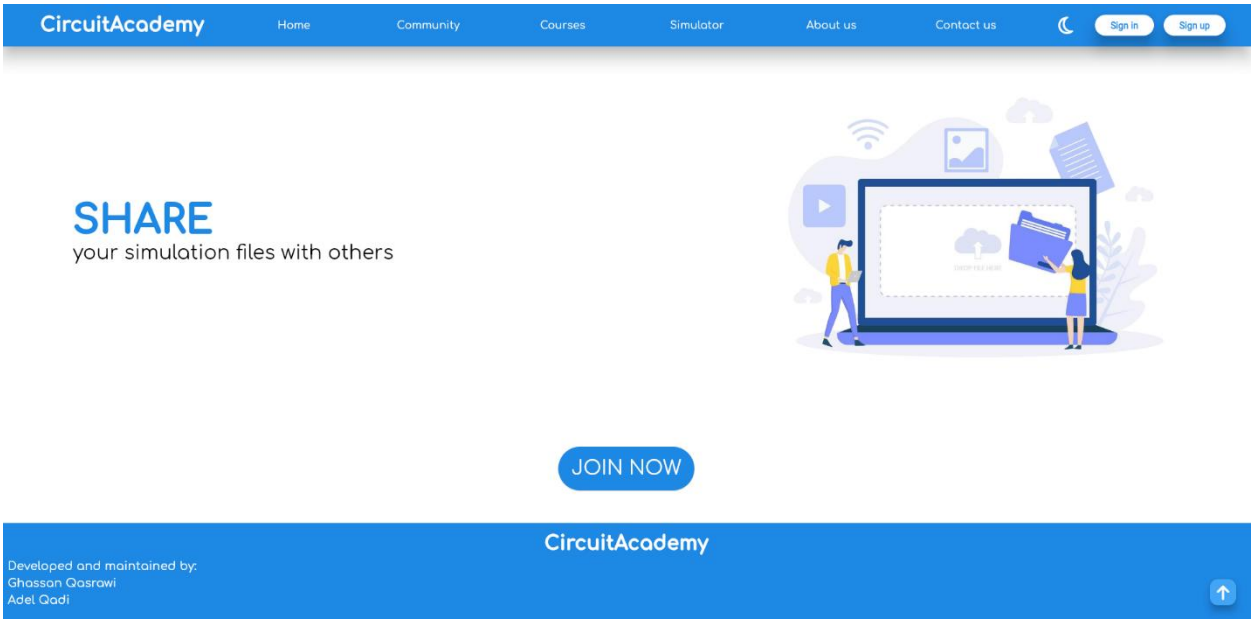


Figure 9: Community section - share

- **Community page (**Not signed in)

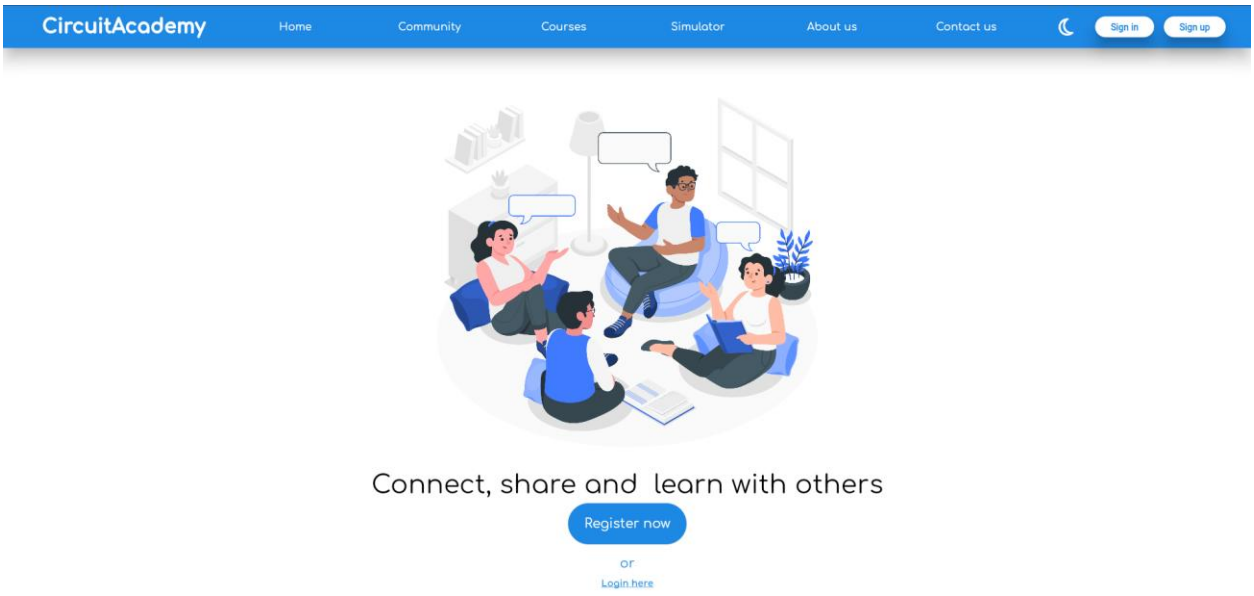


Figure 10: Community page – Not signed in

- **Courses page (**Not signed in): enables users to search through different courses based on title or tag and show the details of each course.

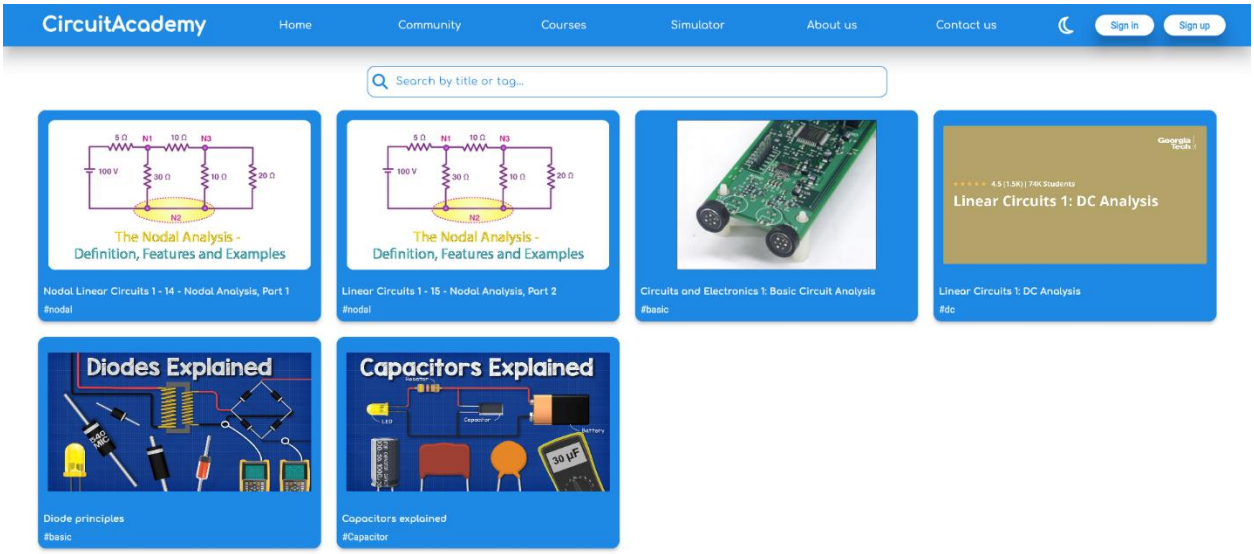


Figure 11: Courses page – Not signed in

- When a course is selected, the details of it appear under the courses section in the following order in the figures:

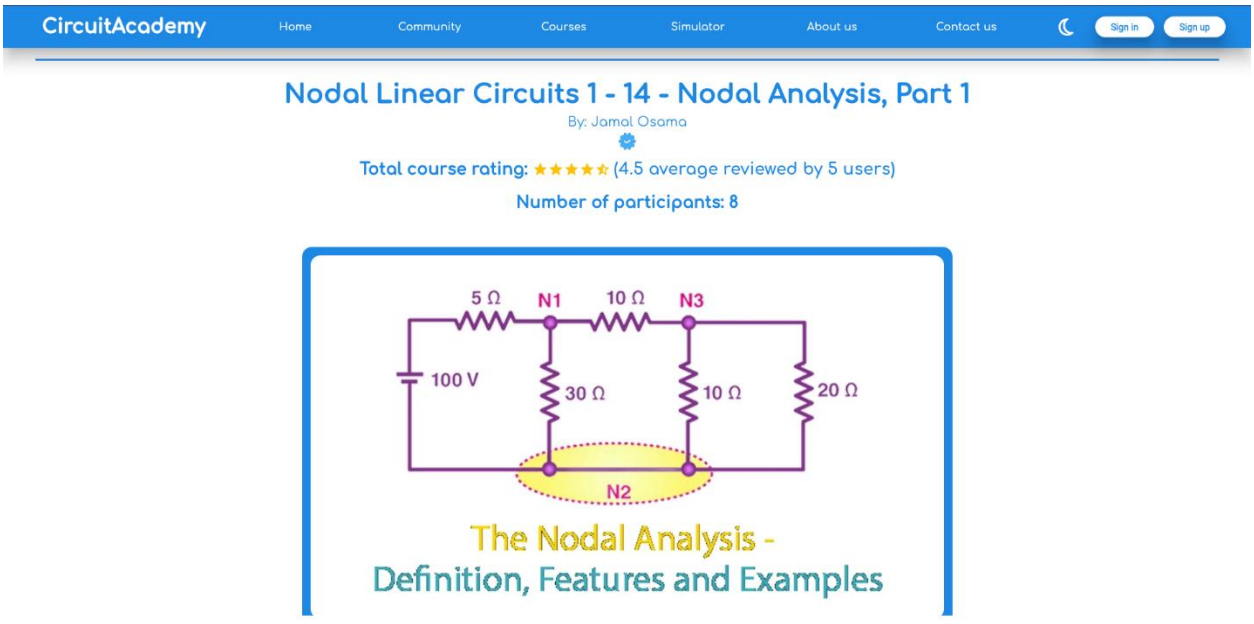


Figure 12: Course details – Not signed in

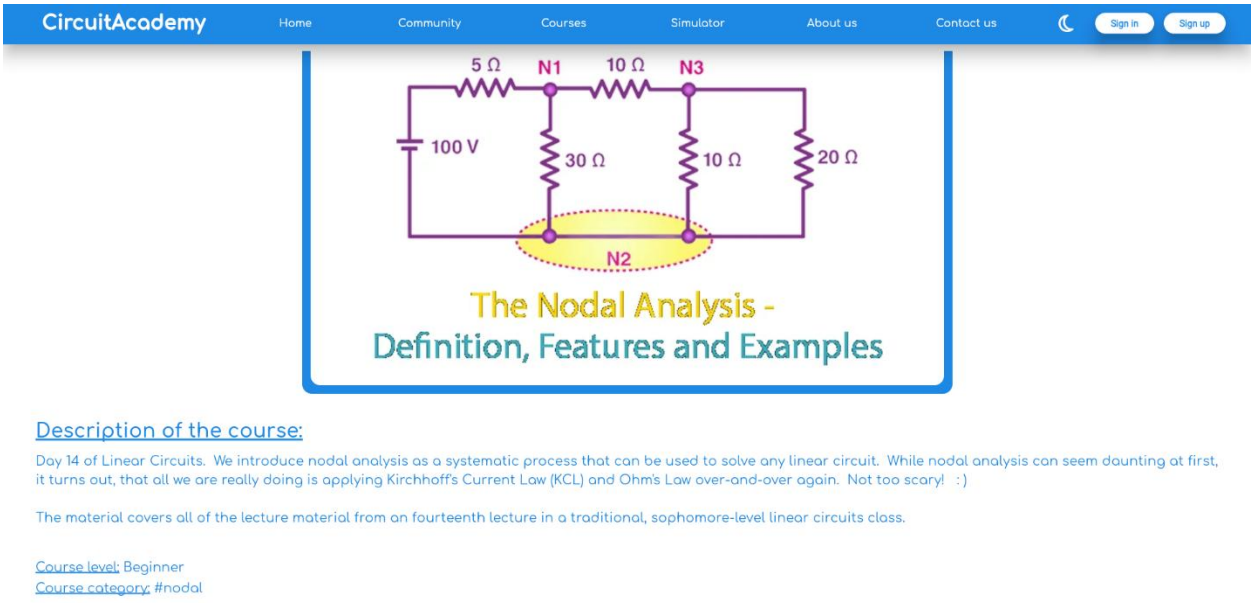


Figure 13: Course details section

- Courses can have multiple reviews to give credibility for each one, improve users experience and enable different course creators check what learners need.

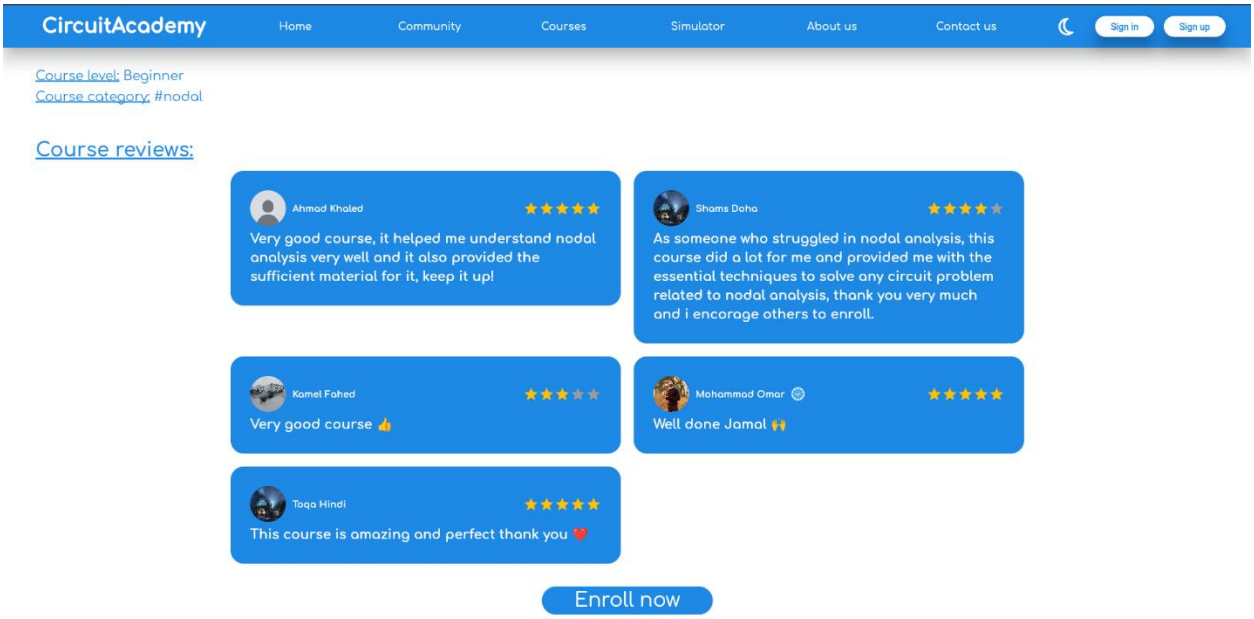


Figure 14: Course reviews

- If the user is not signed in, the site gives a warning for the user to log in if he / she tries to enroll in a course.

Figure 15: Enrolling warning – Not signed in

- **Simulator navigation page**

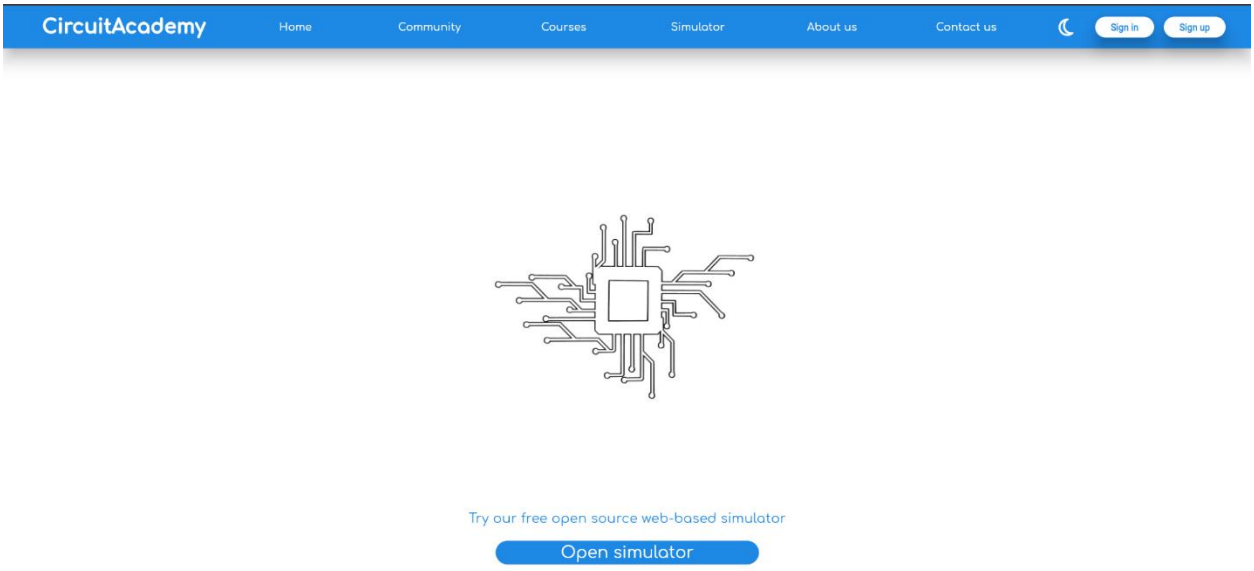


Figure 16: Simulator navigation page

Clicking "Open simulator" Opens the **simulator page** in a new tab of the browser

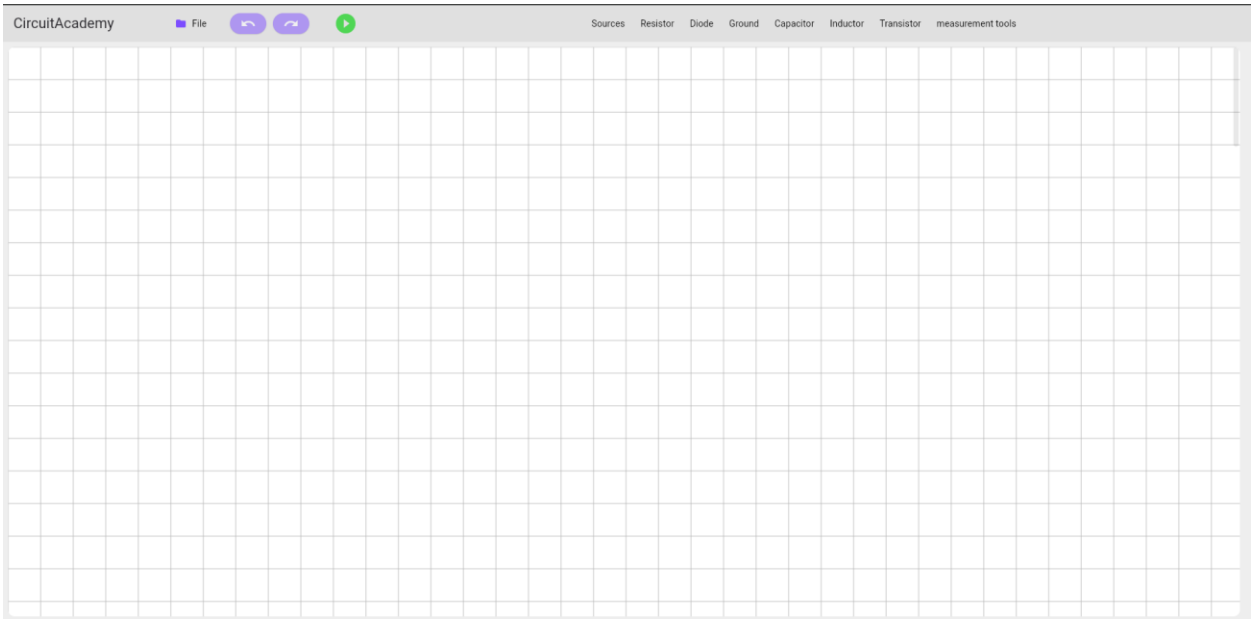


Figure 17: Simulator page

- **About us page:** brief identification of CircuitAcademy.

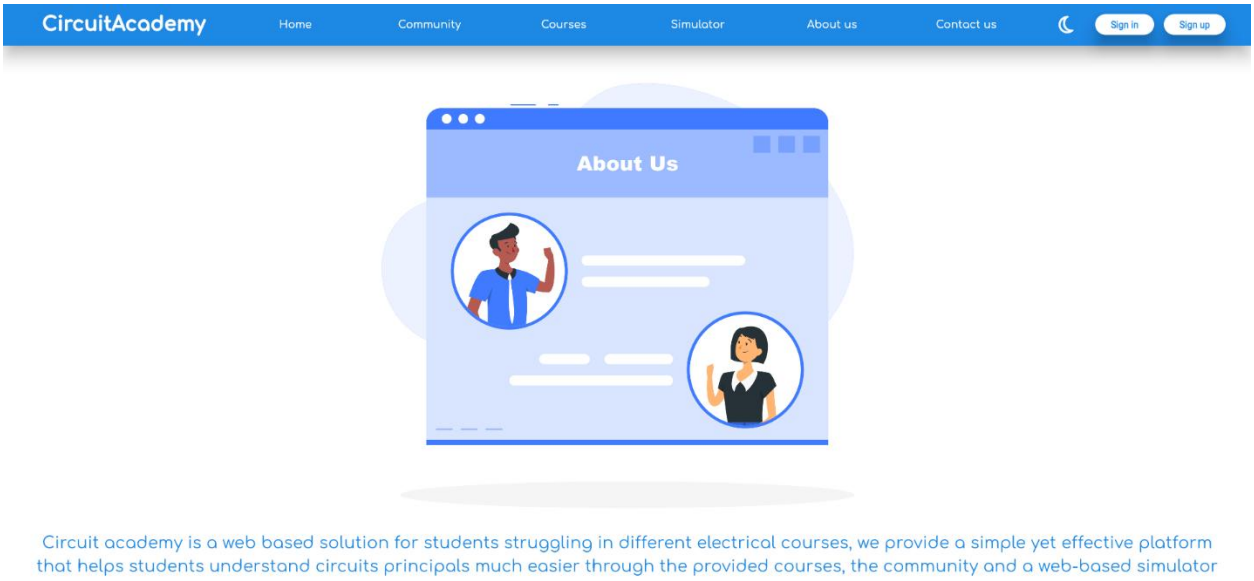


Figure 18:About page

- **Contact us page:** enables different users to send feedback messages to the admins of the platform.

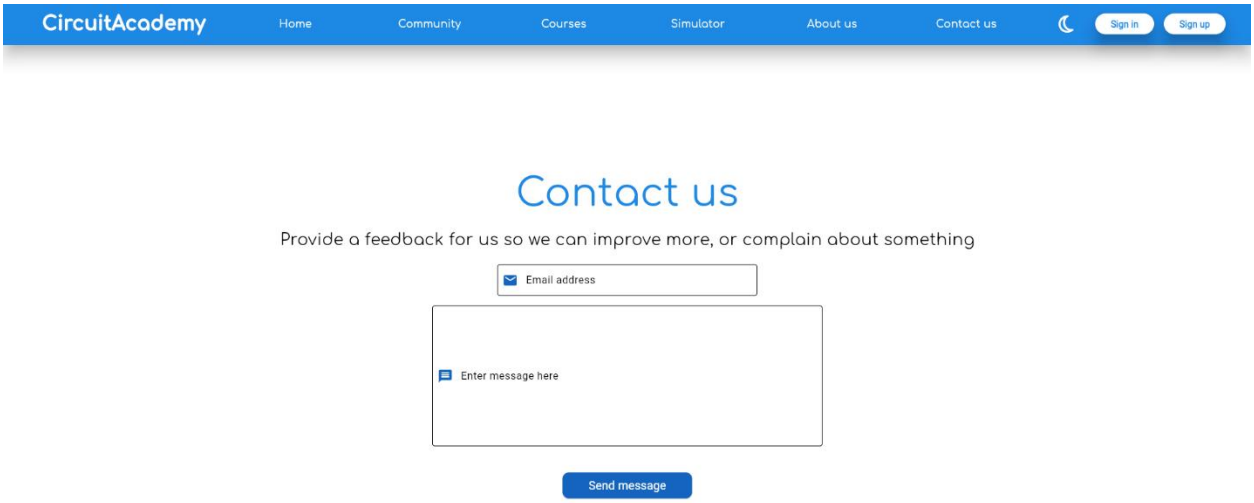


Figure 19: Contact page

- One of the important features of CircuitAcademy is providing both light and dark theme as a way of ensuring good experience for users.

Figure 20: Dark theme sample

- Sign in page

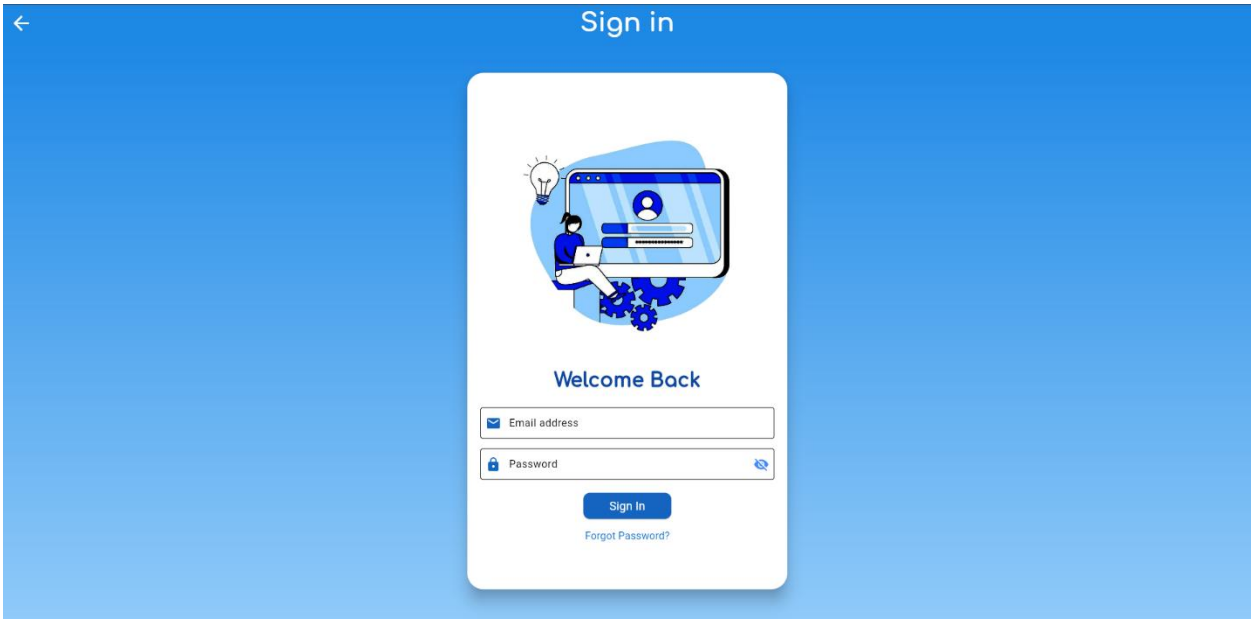


Figure 21: Sign in page - Light

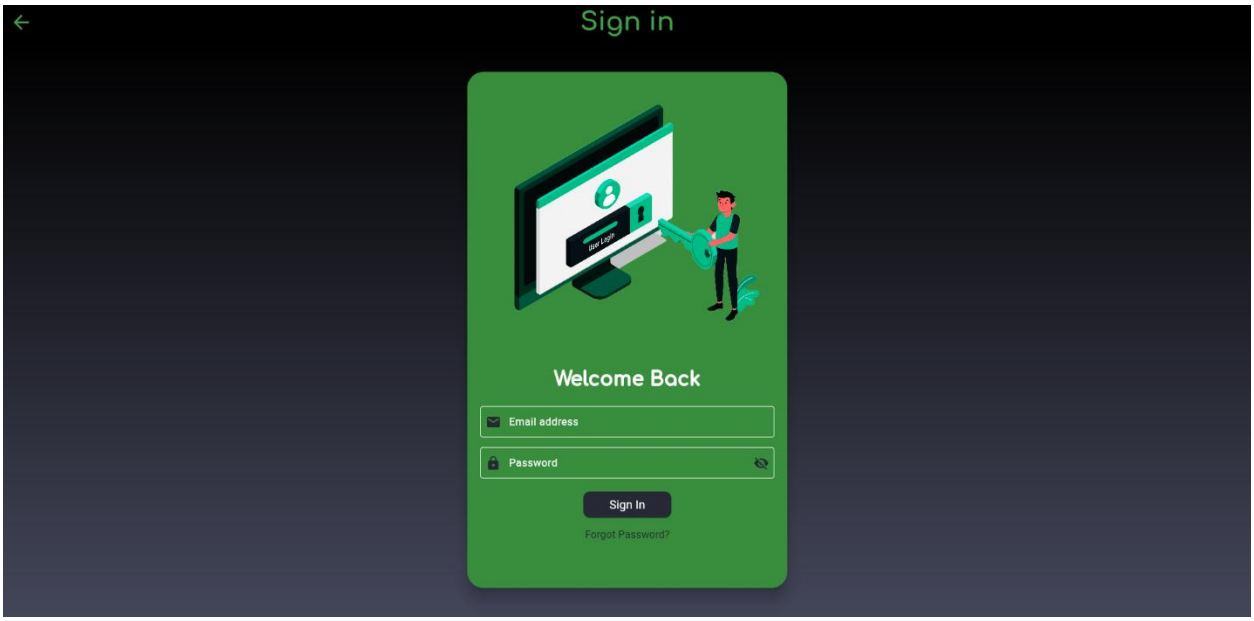


Figure 22: Sign in page - Dark

- Password recovery page

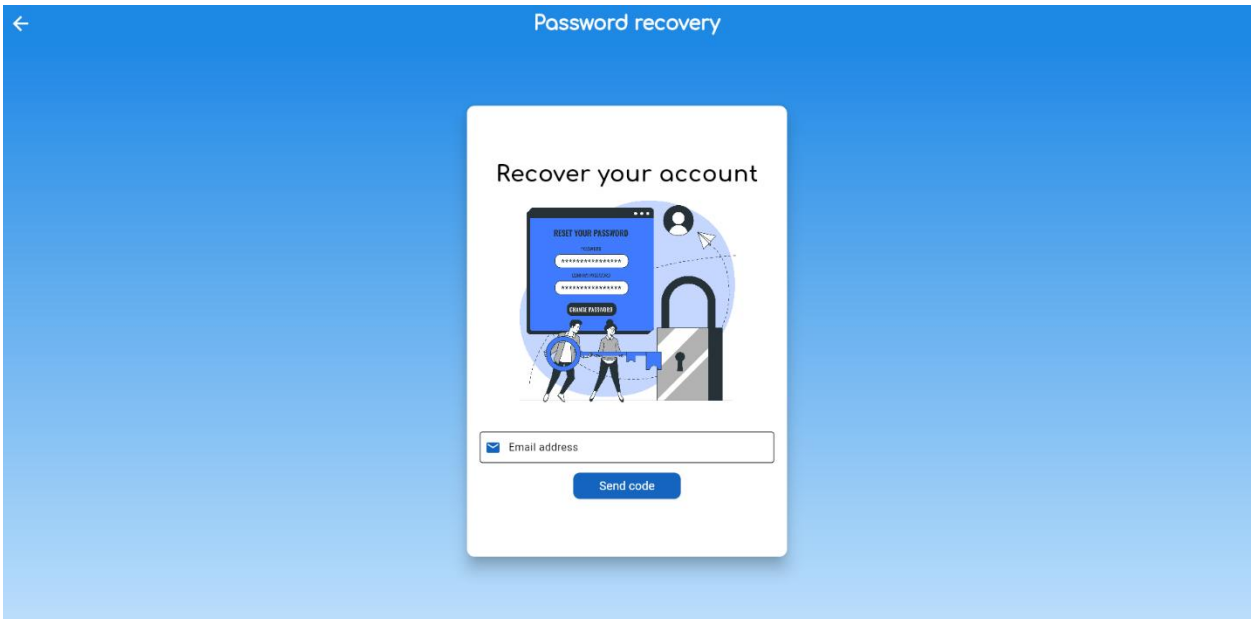


Figure 23: Password recovery page

- Sample received email for password recovery (Personal email account is used to send emails due to phone number adding error to google account)

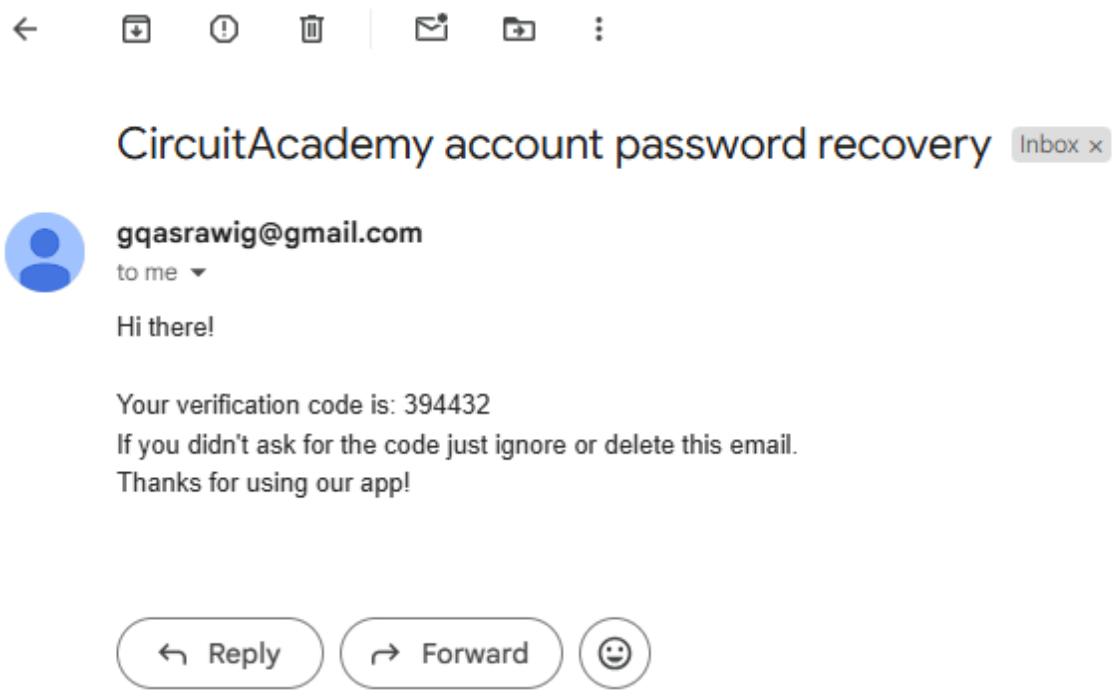


Figure 24: Password recovery sample email

- **Courses page:** Any user can create and publish courses on the platform to ensure maximum benefit and easy access.

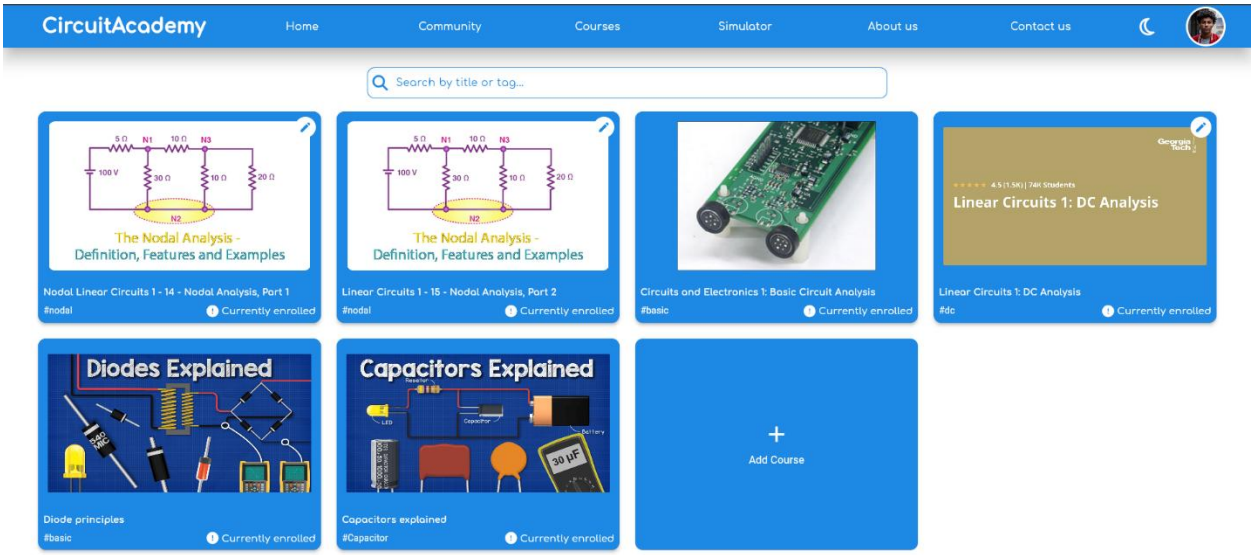


Figure 25: Courses page - Signed in

- Course details section: When the user selects a course, the course details section shows the contents of the course in addition to the course's overview and reviews.

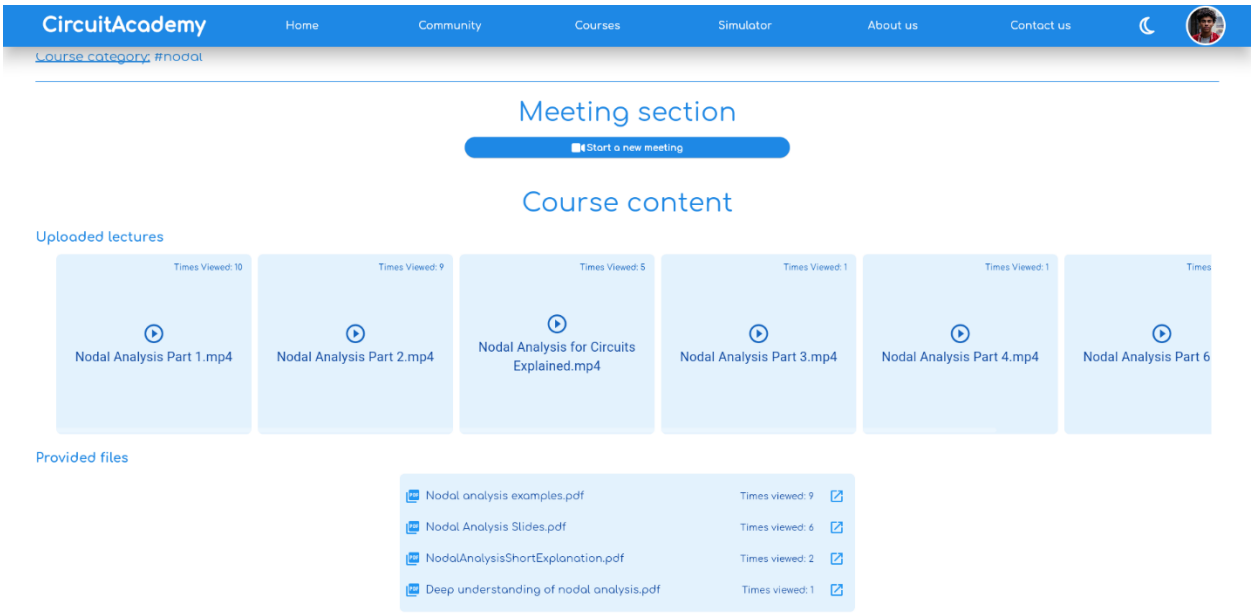


Figure 26: Course content section - course details

- Examples section: Shows a set of examples that learners can solve and check their solution in the simulator page.

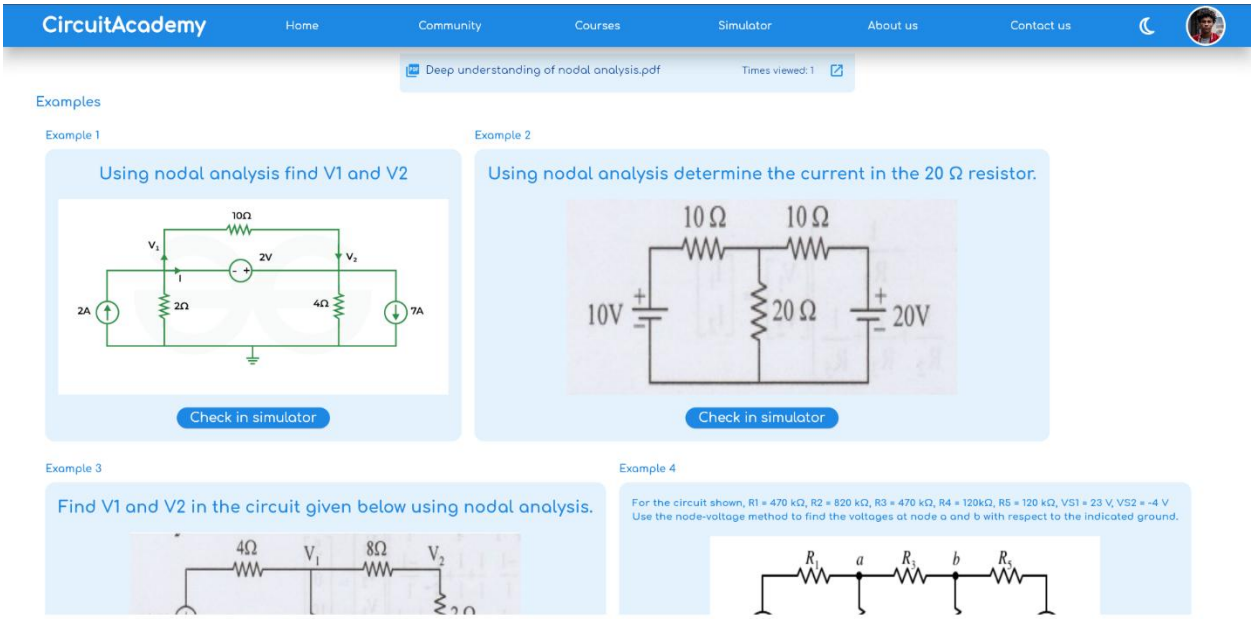


Figure 27: Examples section - 1

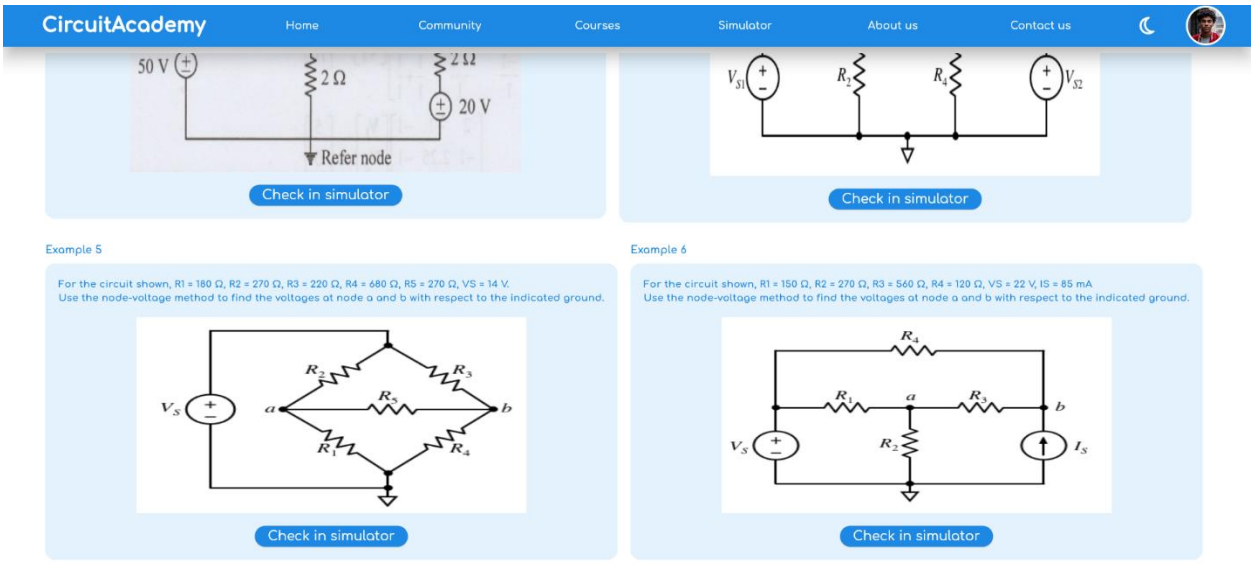


Figure 28: Examples section - 2

Clicking on the “Check in simulator” button navigates the user to the simulator showing the example with ability to simulate it.

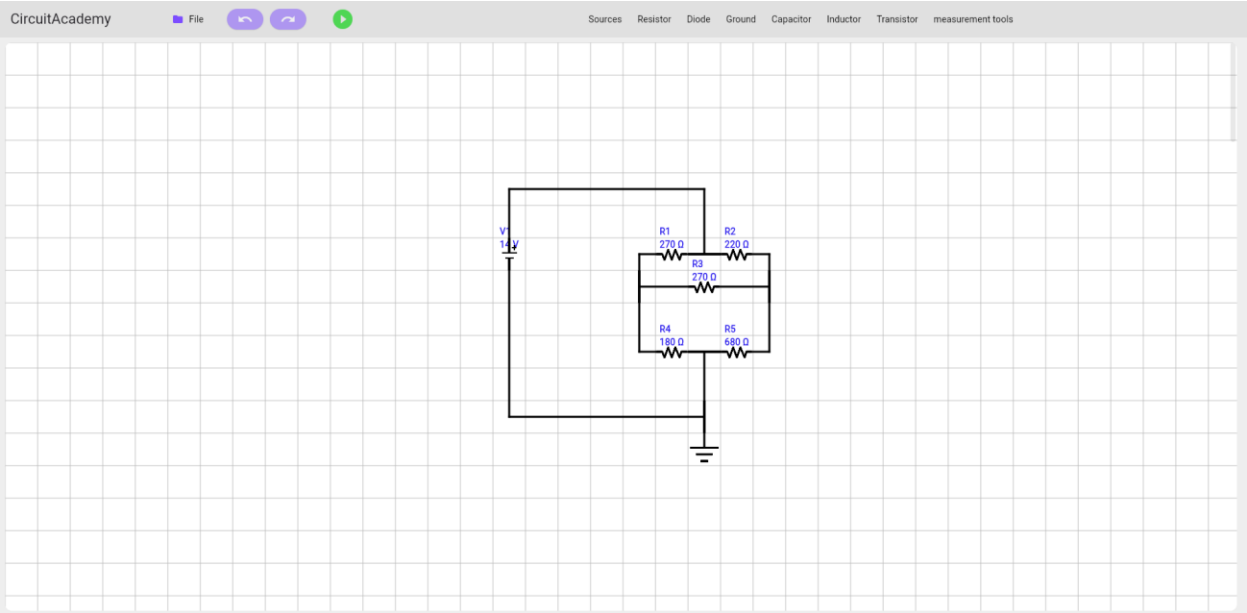


Figure 29: Simulator loaded with example

Clicking on a lecture video opens a dialog for viewing it

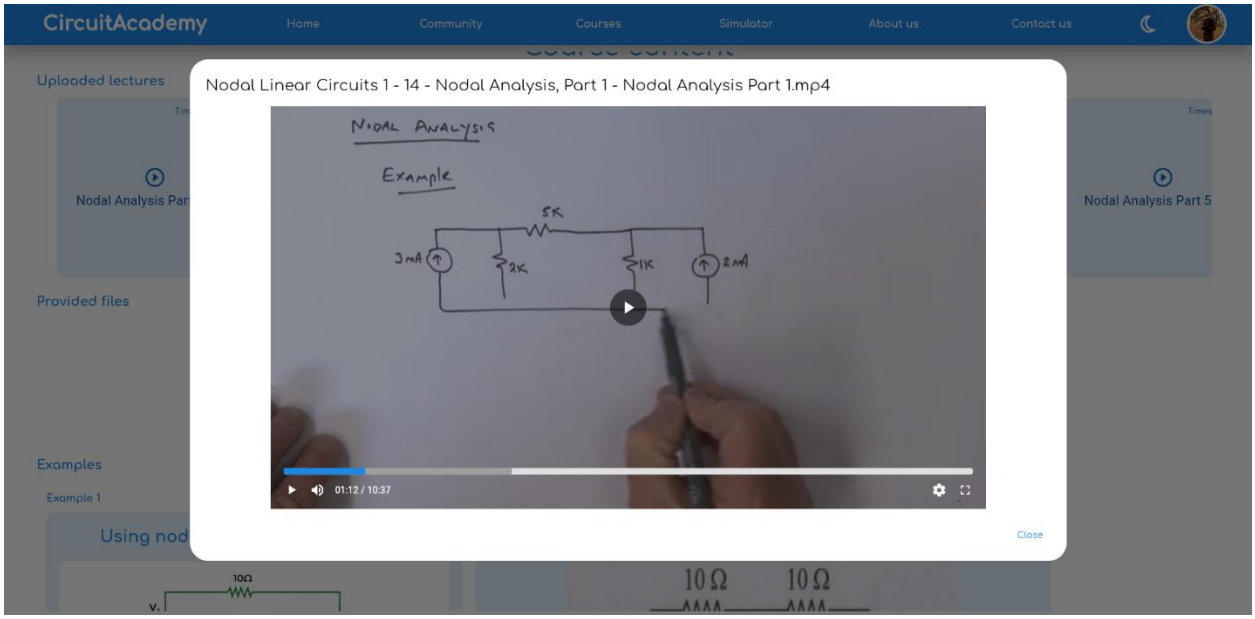


Figure 30: Lecture viewing

- Clicking on the “Start a new meeting” button opens a lecturer driven meeting in a new tab of the browser where other users can join and participate in a real-time educational operation.

Figure 31: Meeting screen - no participants

- For a user to join a meeting, the meeting ID for the specific meeting should be inserted in the following text field which appears to users enrolled in the course and not the course creator.

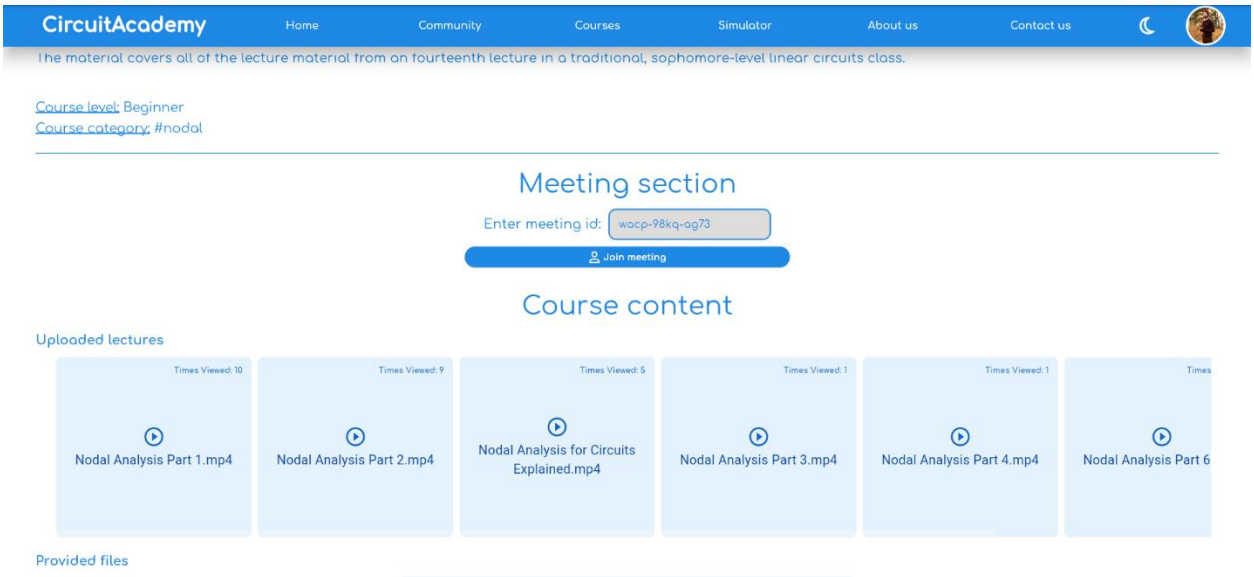


Figure 32: Joining a meeting from other user view

- The following image shows an example of multiple users in a meeting screen. (They can join a meeting using the meeting ID by sharing it on the community page for the course or sending it to specific users via messaging services. (Camera is running but covered)

Figure 33: Meeting with 2 participants

- When trying to use the camera or microphone, permission is requested

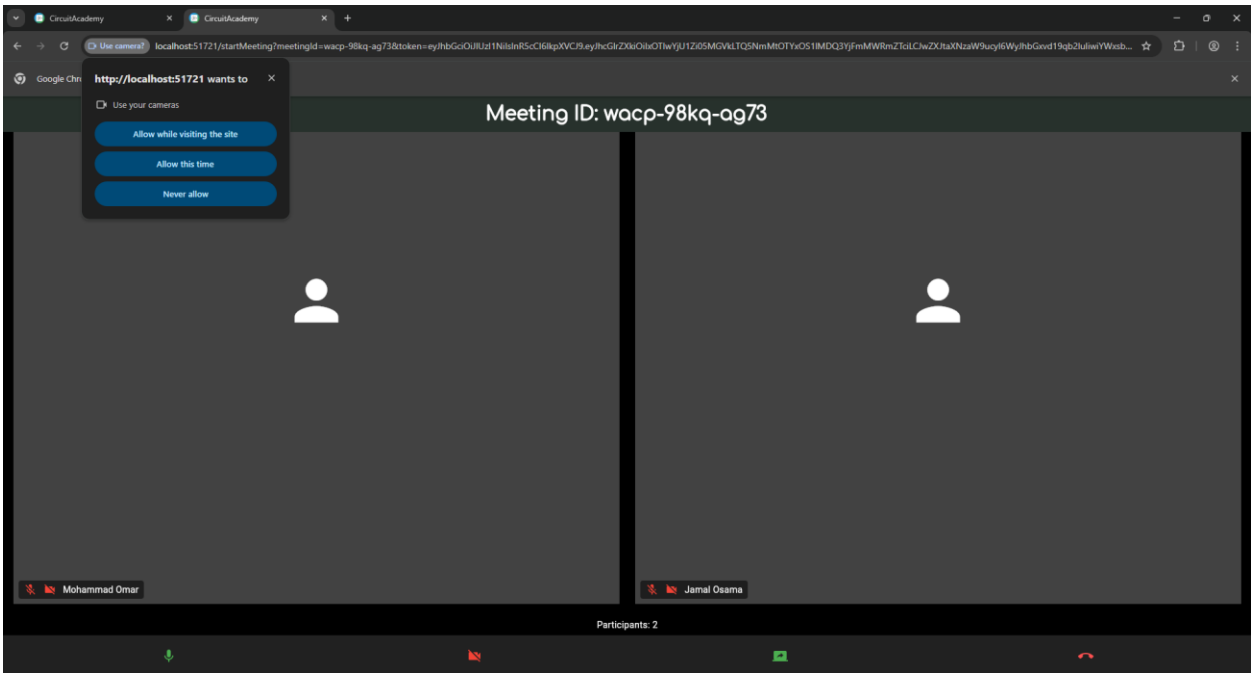


Figure 34: Camera permission request

- Screen sharing can be achieved by “share screen” button, when clicked user can share his screen via the following dialog which enables tab, window, or entire screen share

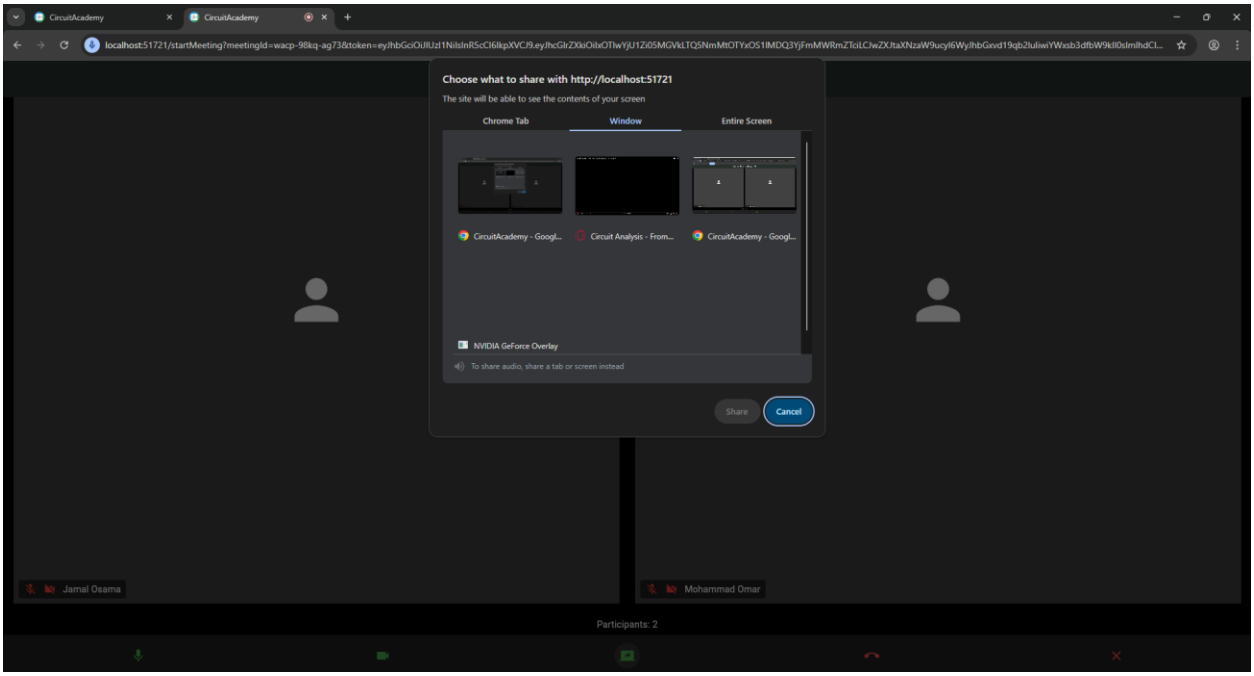


Figure 35: Sharing options

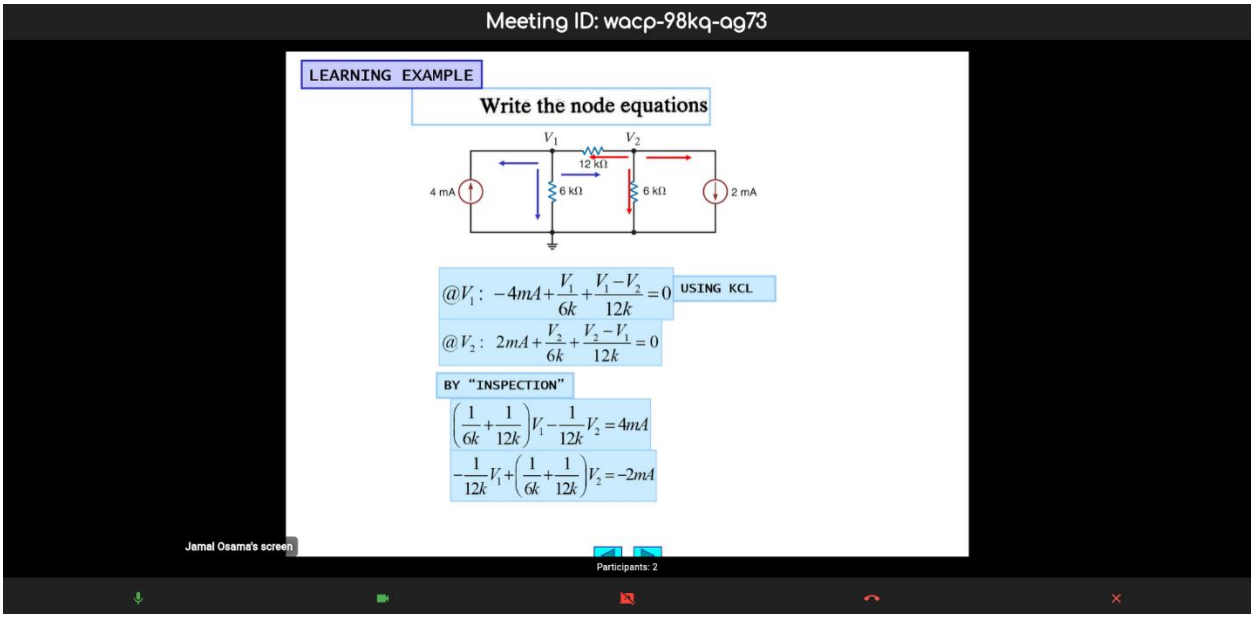


Figure 36: Screen share

When the screen is shared participants still appear under the shared screen

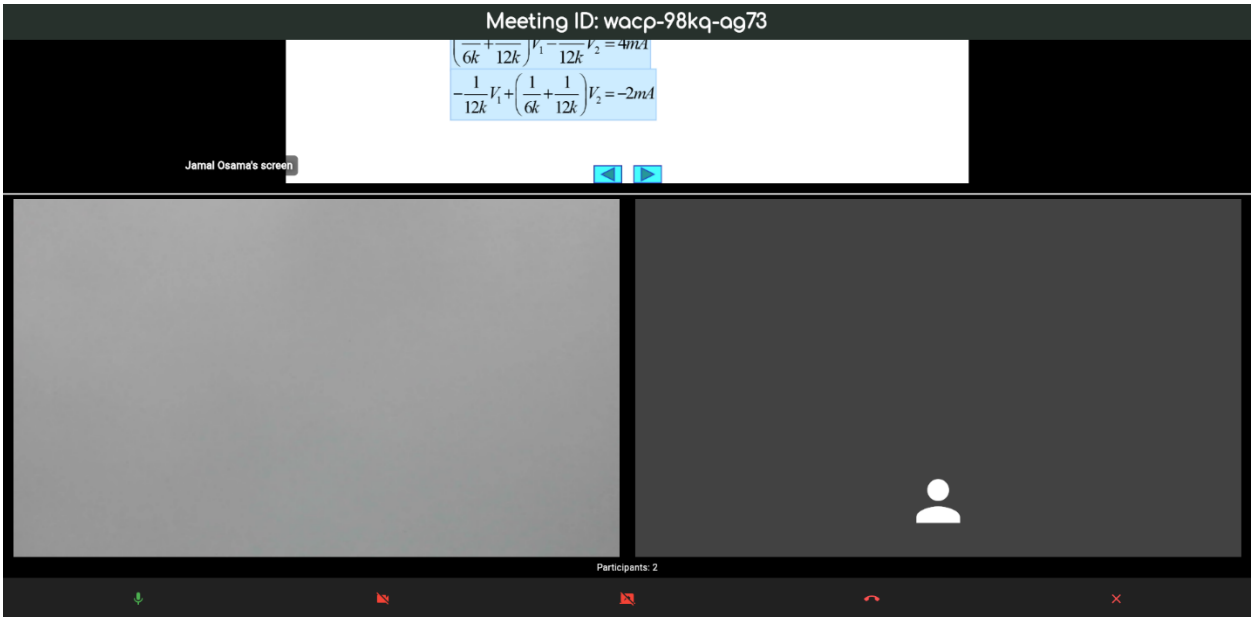


Figure 37: participants with screen share

Only the meeting host has the option to end the meeting

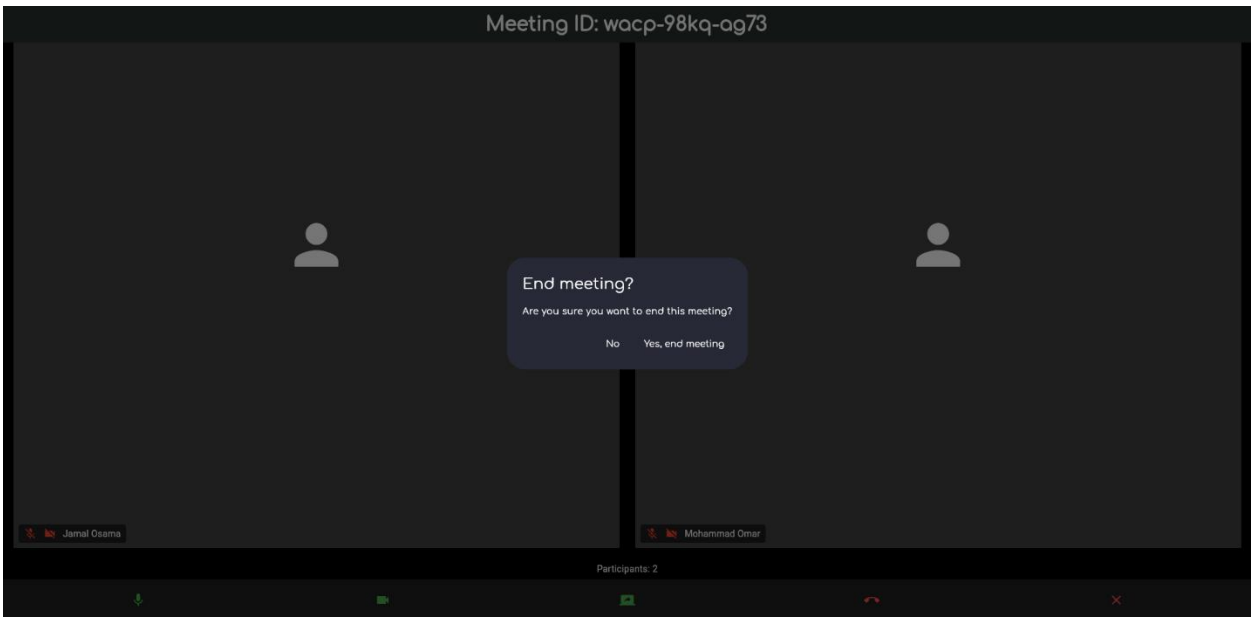


Figure 38: End meeting

Users will be redirected back to the meeting section of the course.

- Edit course section where the course creator can edit his course, add or delete examples, upload lectures and files

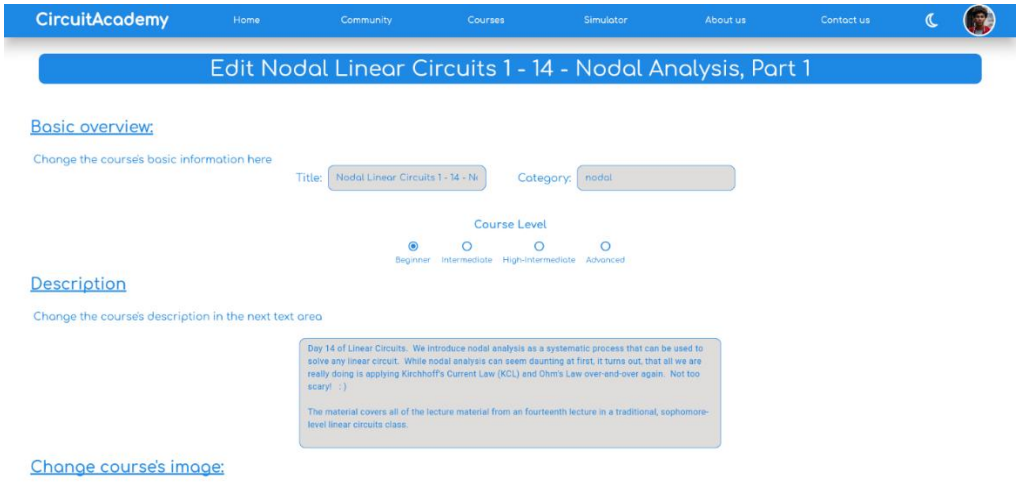


Figure 39:Course edit section - 1

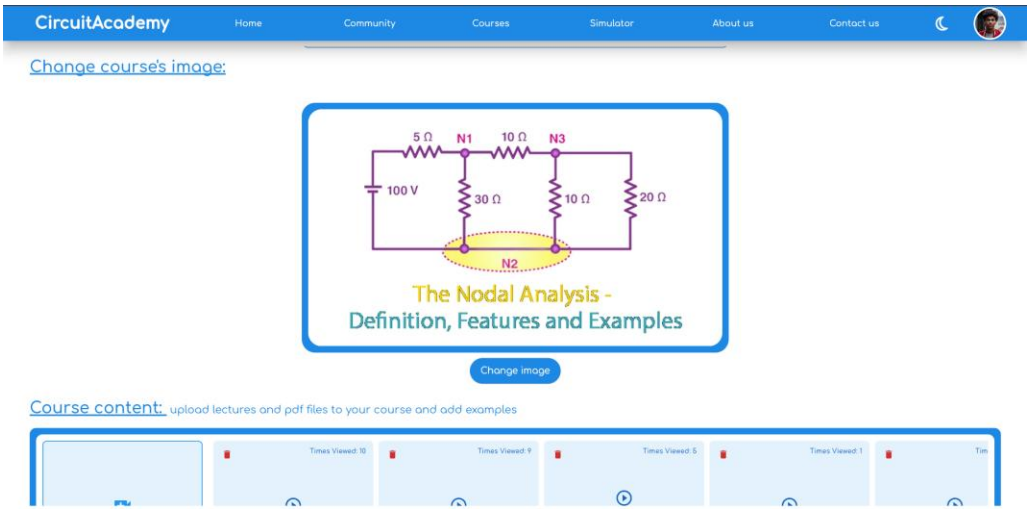


Figure 40: Course edit section - 2

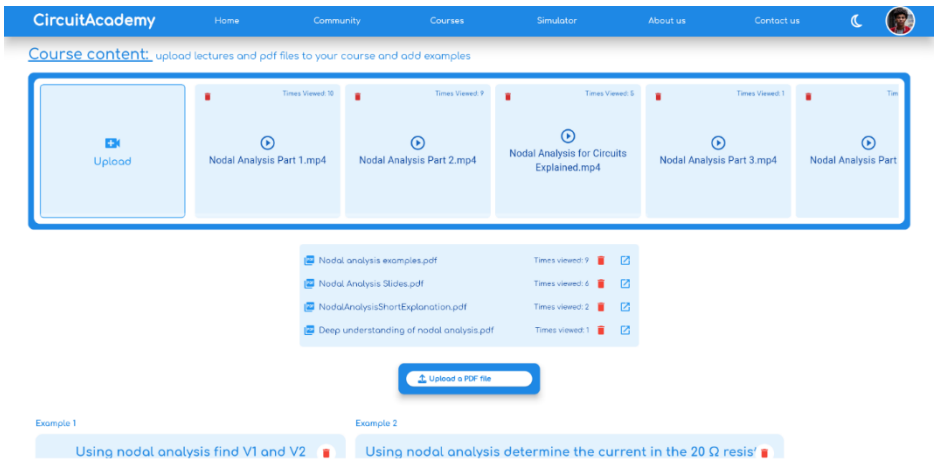


Figure 41: Course edit section - 3

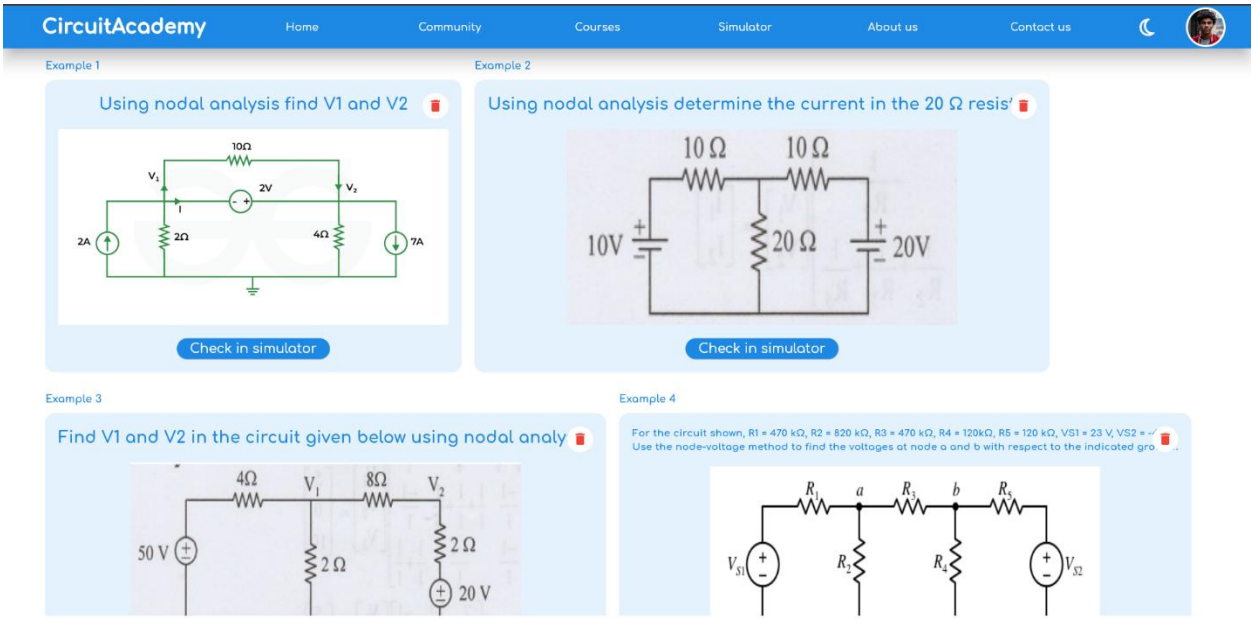


Figure 42: Course edit section - 4

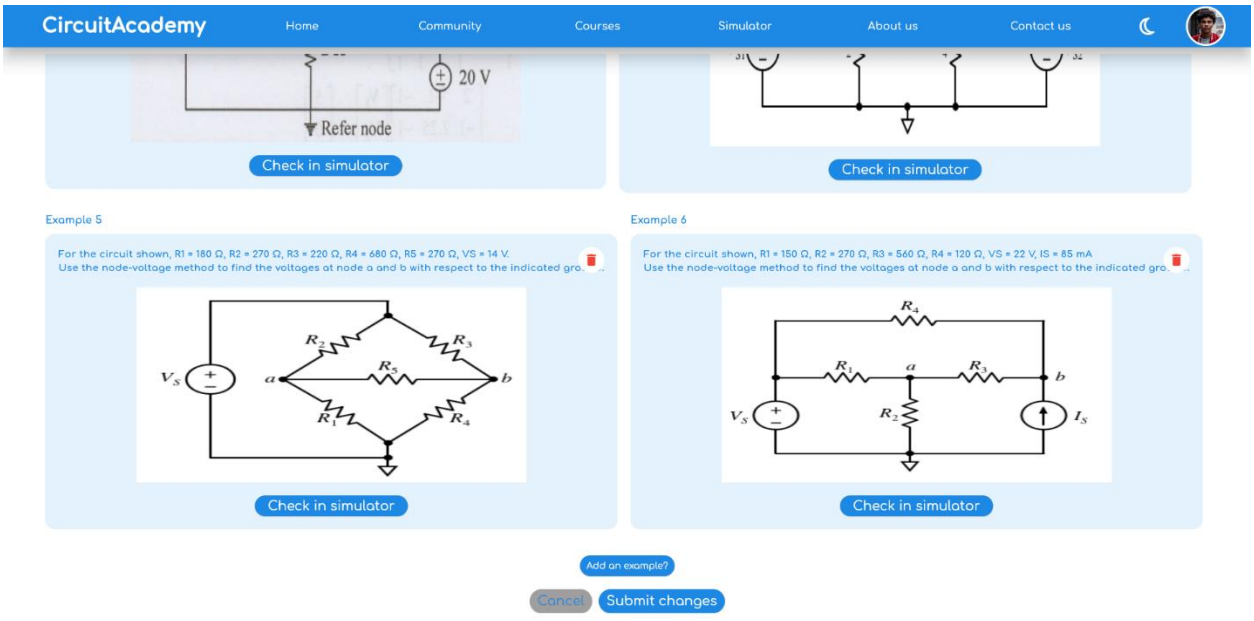


Figure 43: Course edit section - 5

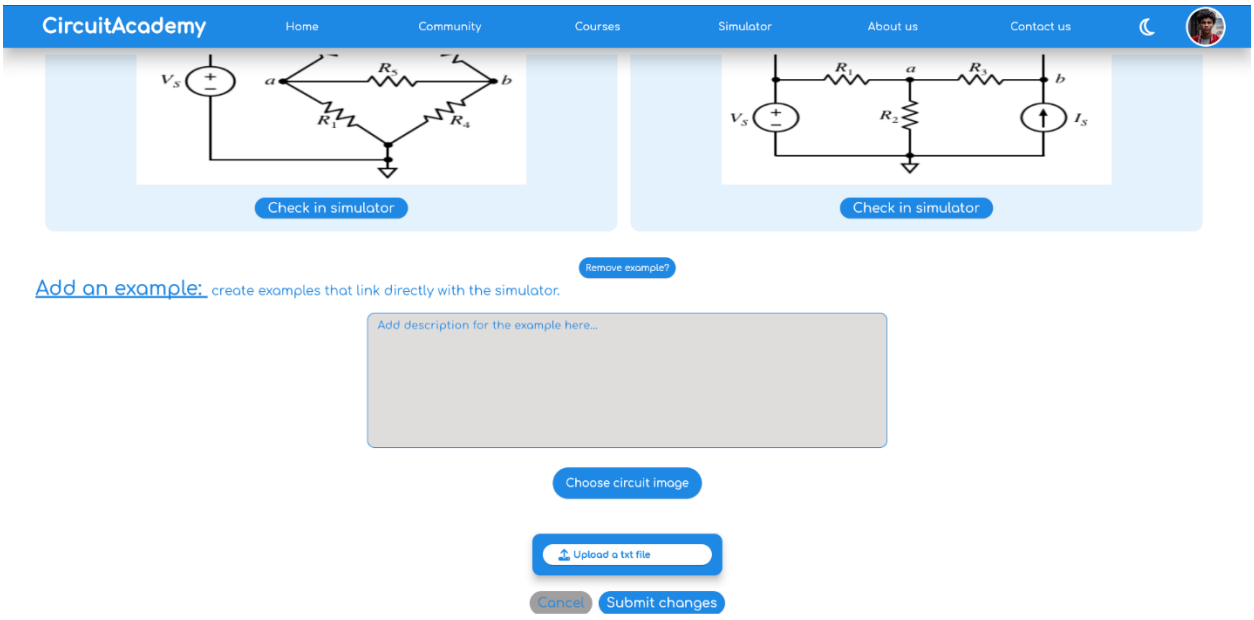


Figure 44: Course edit section - 6: Adding an example

The uploaded text file is used by the simulator to handle the example when navigating to simulator page.

- **Course creation section**

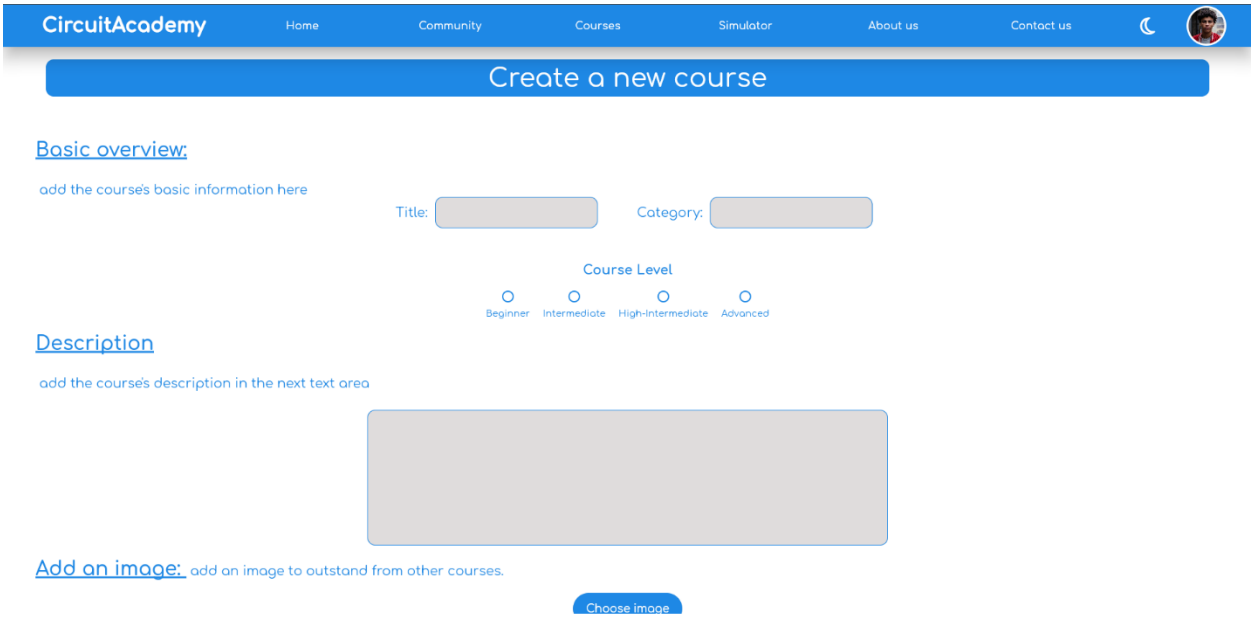


Figure 45: Course creation section - 1

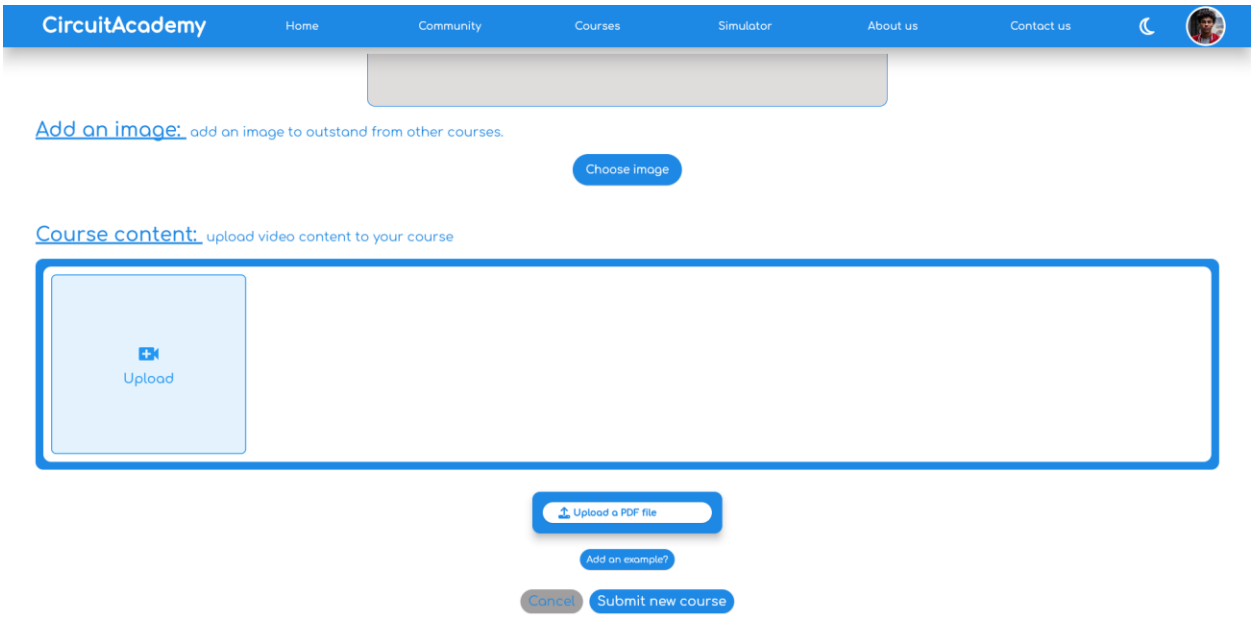


Figure 46: Course creation section – 2

- Adding an example for the newly added course:

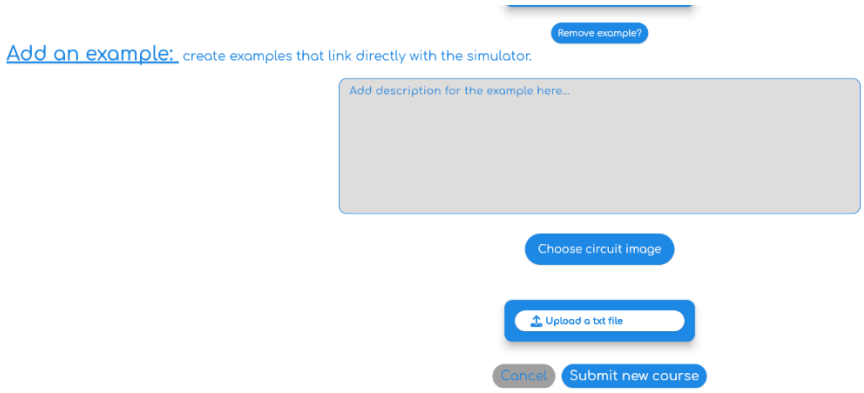


Figure 47:Course creation section - 3

- Users can filter courses based on their titles or tags

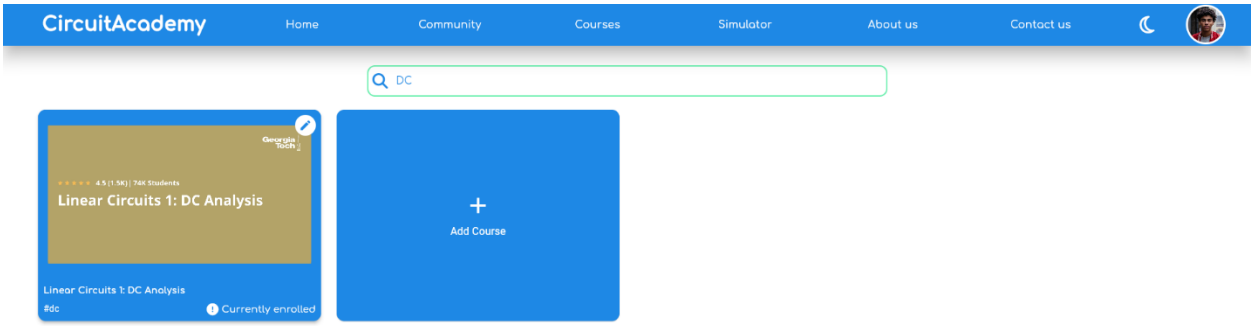


Figure 48: Course searching

- **Community page:** Each course is connected to a community group where learners and lecturers can communicate easily and effectively, the user first chooses an enrolled course from the list on the left which shows the user course's subfeed and other enrollees in the same course.

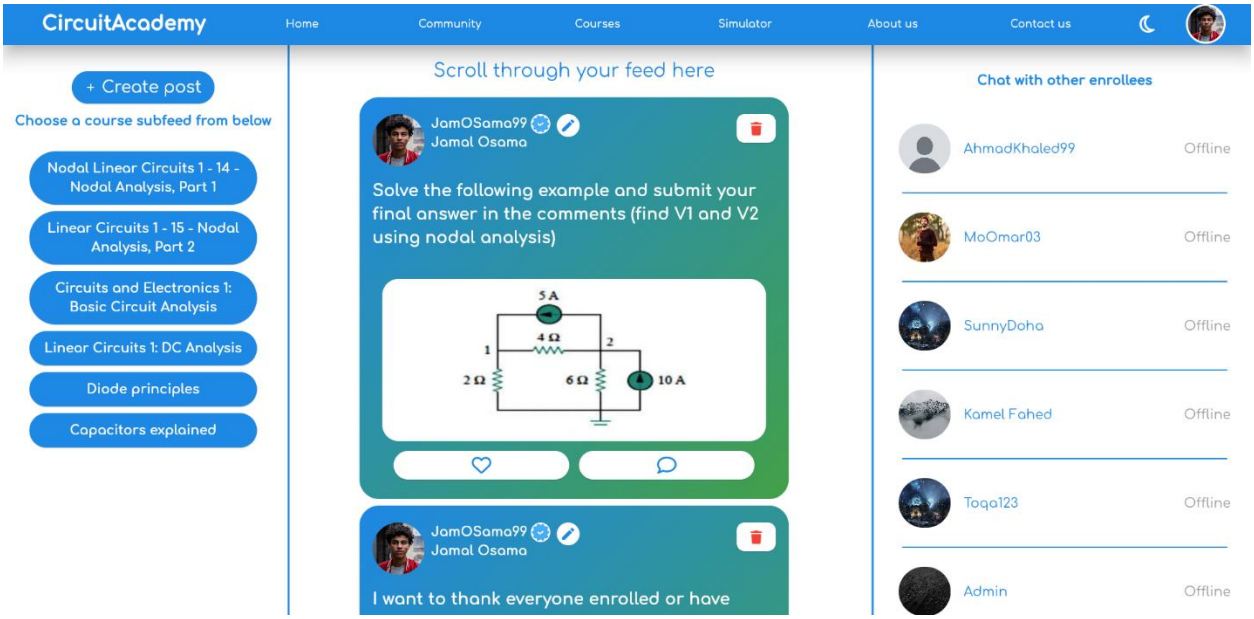


Figure 49: Community page

The icons next to the shown user mean the following:

Indicates the user is a verified lecturer and has submitted what is required for it and got approved by the admins which gives credibility for created courses.

Indicates the user is the creator of the course.

Example of other course group showing comments on a post

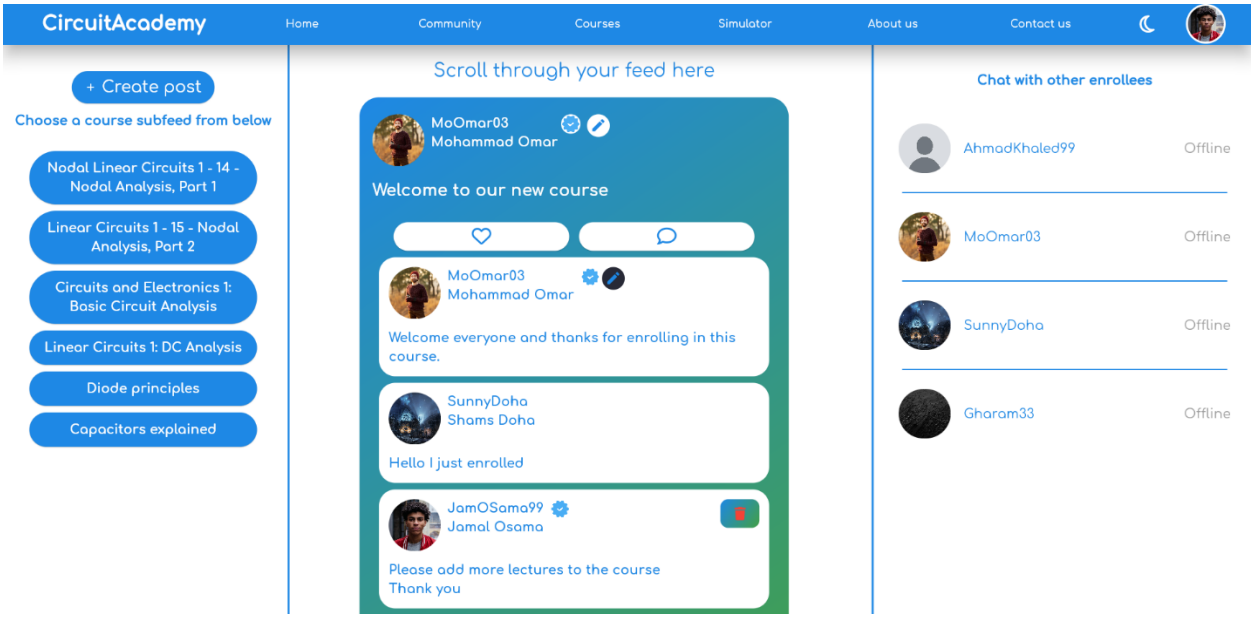


Figure 50: Community page - comments

- Post creation dialog: enables users to create and share posts in the specific course group with the ability to upload images or simulation files extending sharing between users

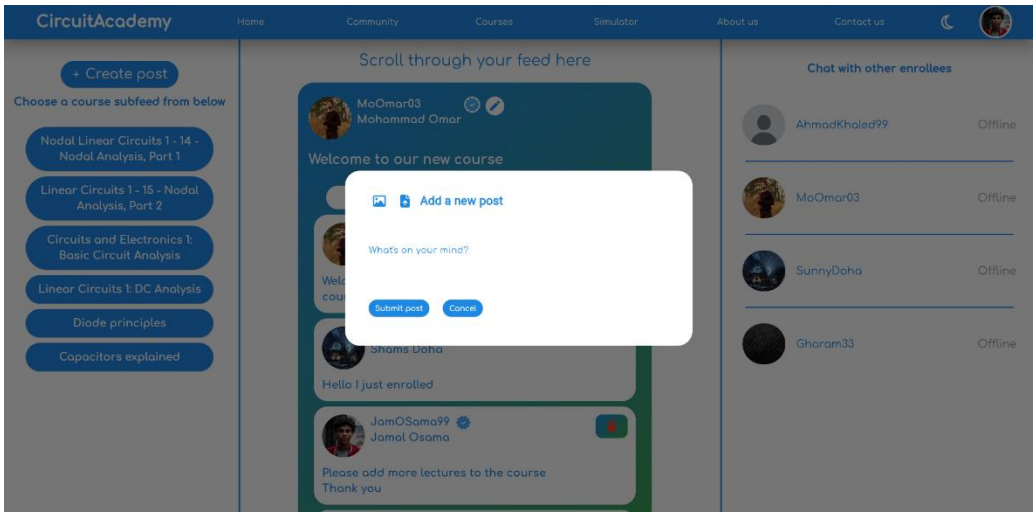


Figure 51: Post creation dialog

Sample file post: after uploading a file to the post, users can download the file check it in the simulator.

Figure 52: Post with file example

Clicking on a user in the right section enables real-time messaging between the two enrollers.

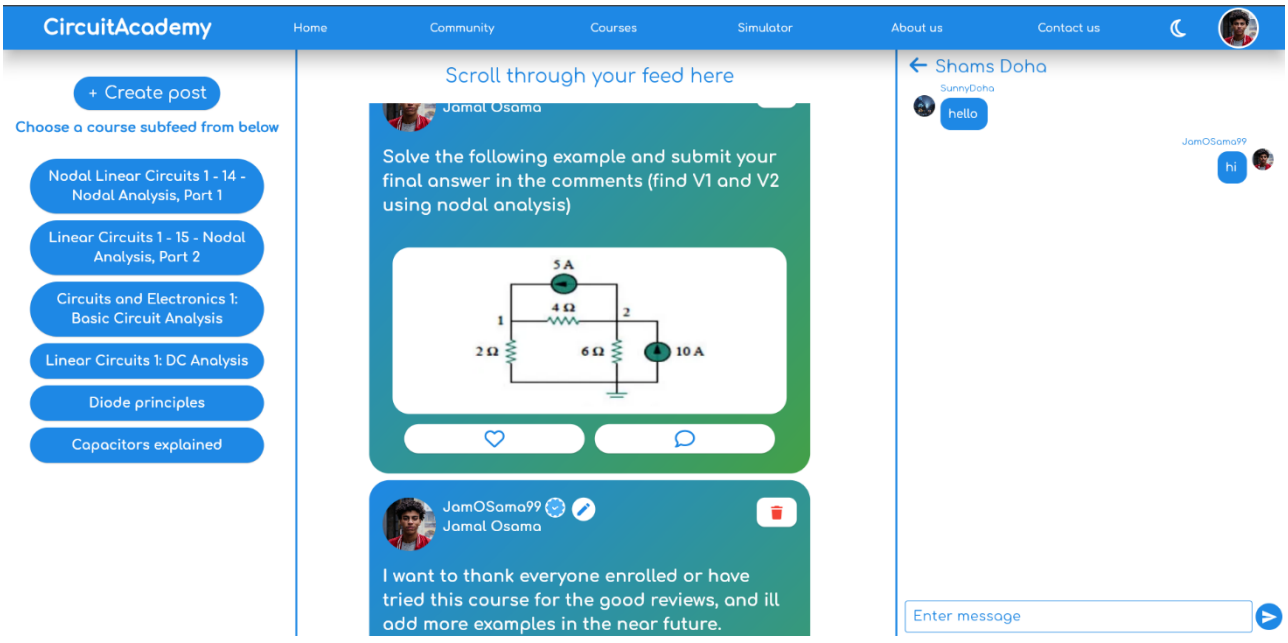


Figure 53:Community page showing chat

- The web platform also listens to notifications if the user allows them via the browser pop-up.

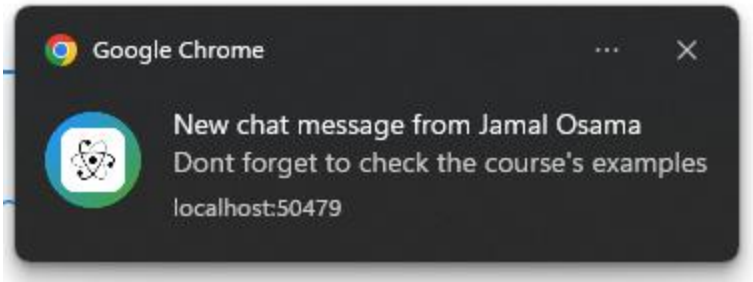


Figure 54: Web notification example

- Edit profile screen: Allows users to edit their information, change their profile image, and upload a certificate approving the user is a valid lecturer in order to request a verified mark from the admins.

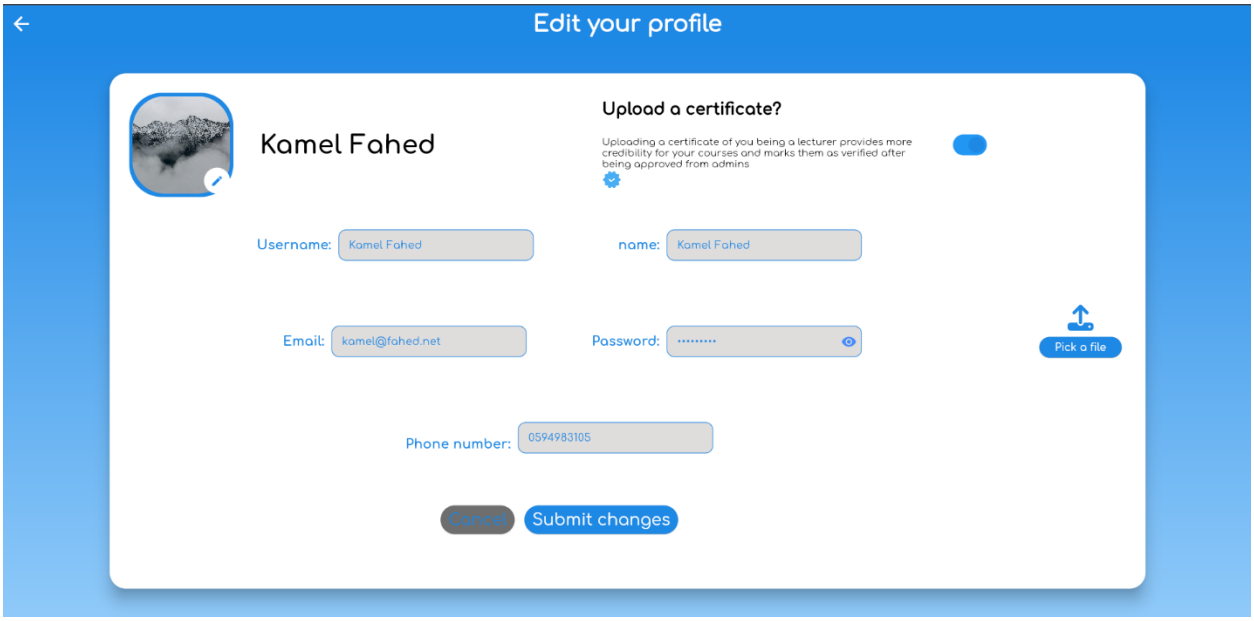


Figure 55: Edit profile page

In case the user has already uploaded a certificate:

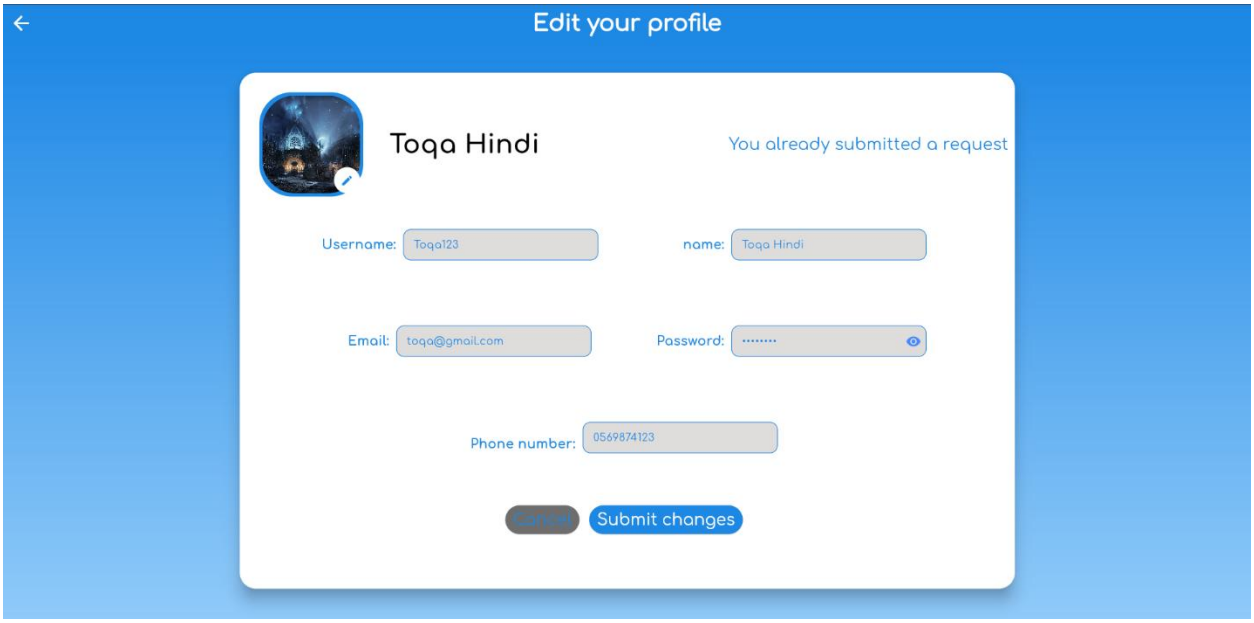


Figure 56: Edit profile - Request sent

Or if the user request was approved by the admins:

Figure 57: Edit page - Verified user

- Profile menu: enables users to either edit their profiles or sign out of the platform when clicked.

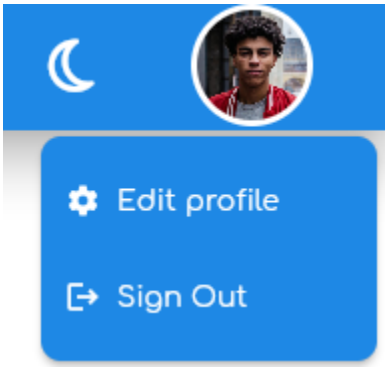


Figure 58: Profile menu

The next figures describe the administrator user interfaces of the platform.

- Accessing administrator pages: An admin can access administration pages using the profile menu option “Go to admin panel”.

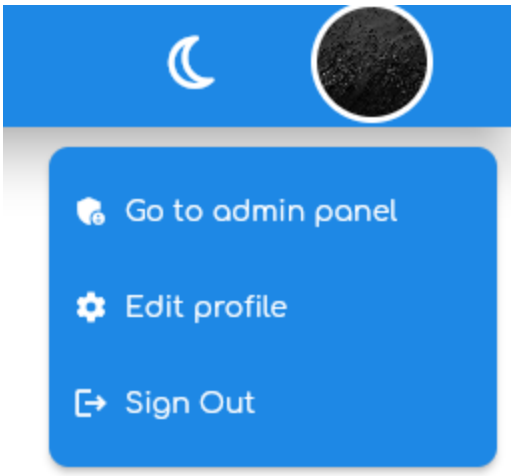


Figure 59: Admin profile menu

- The first page is the admin dashboard where it shows an overall overview of the platform, recent posts and comments, and describing charts for courses, posts and comments.

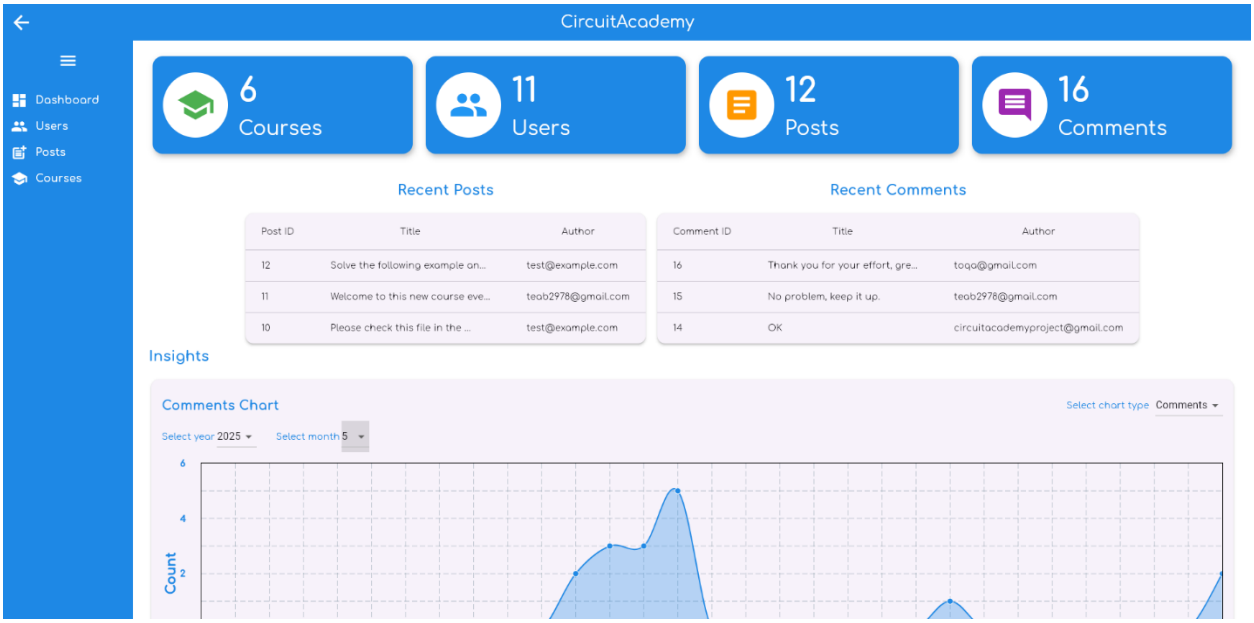


Figure 60: Admin dashboard

- The chart shows created courses, posts or comments through a selected month in a selected year.

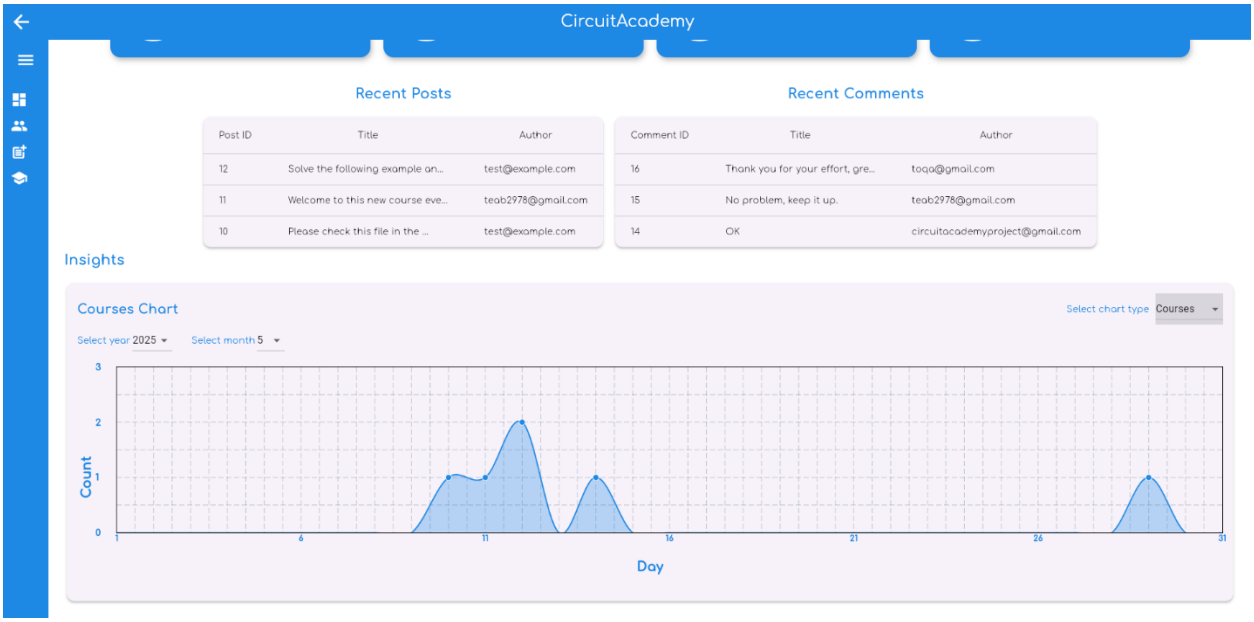


Figure 61: Courses chart

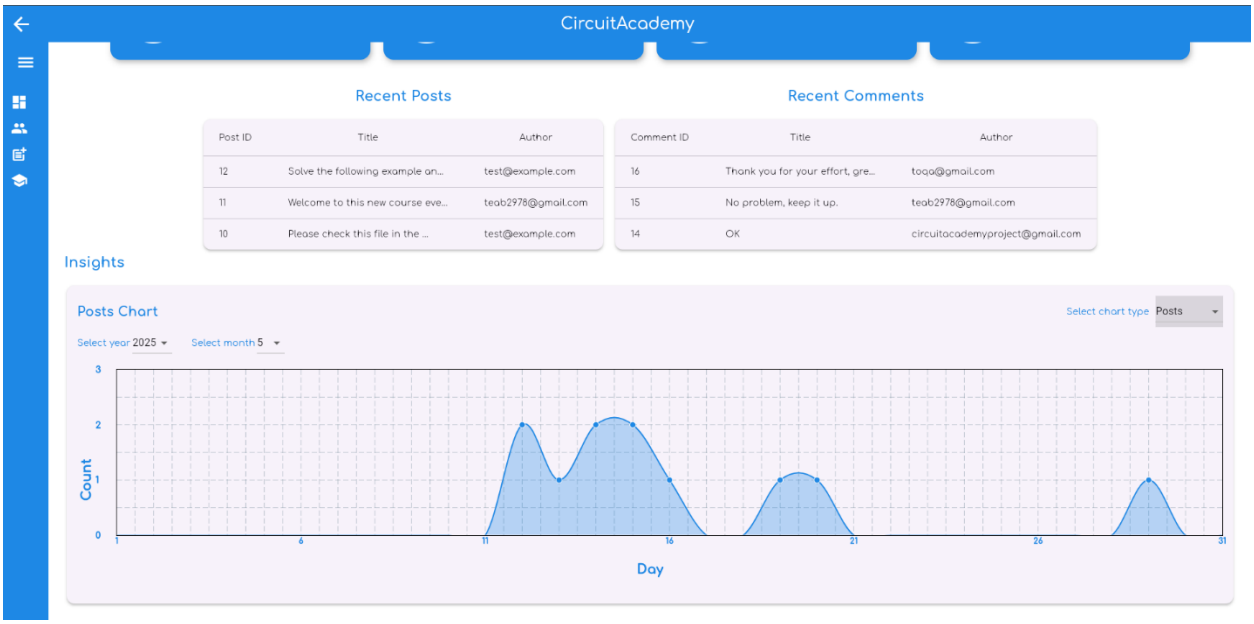


Figure 62: Posts chart

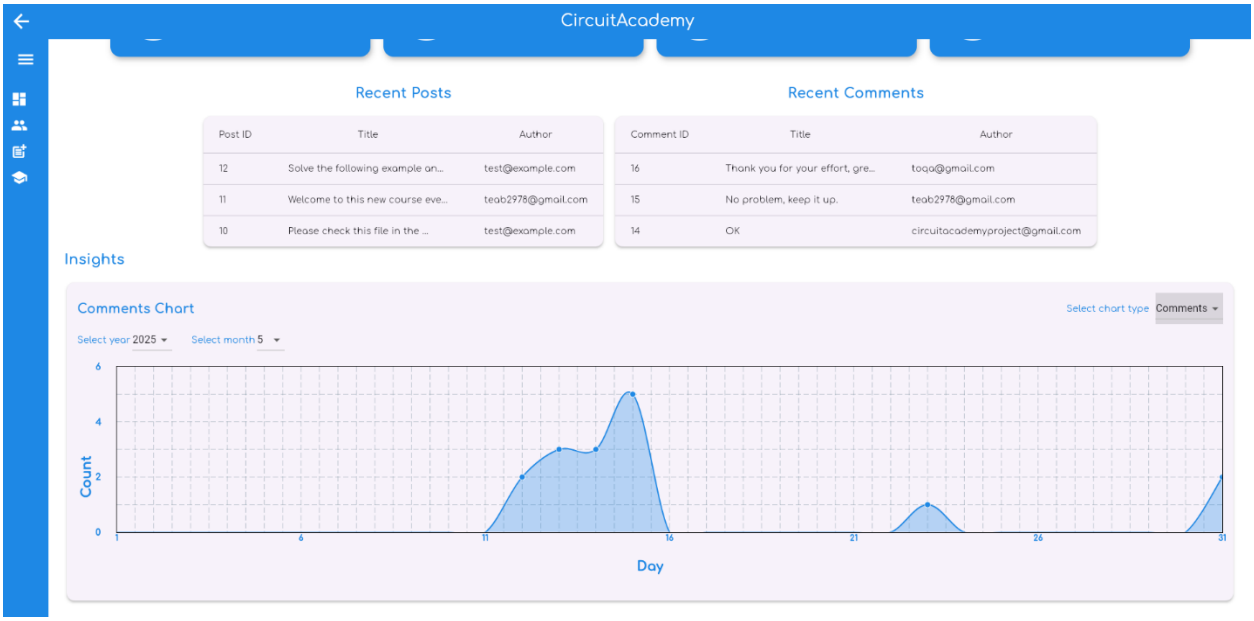


Figure 63: Comments chart

- **Users page**: Shows verification requests ordered from newest to oldest and other information about all users using the platform.

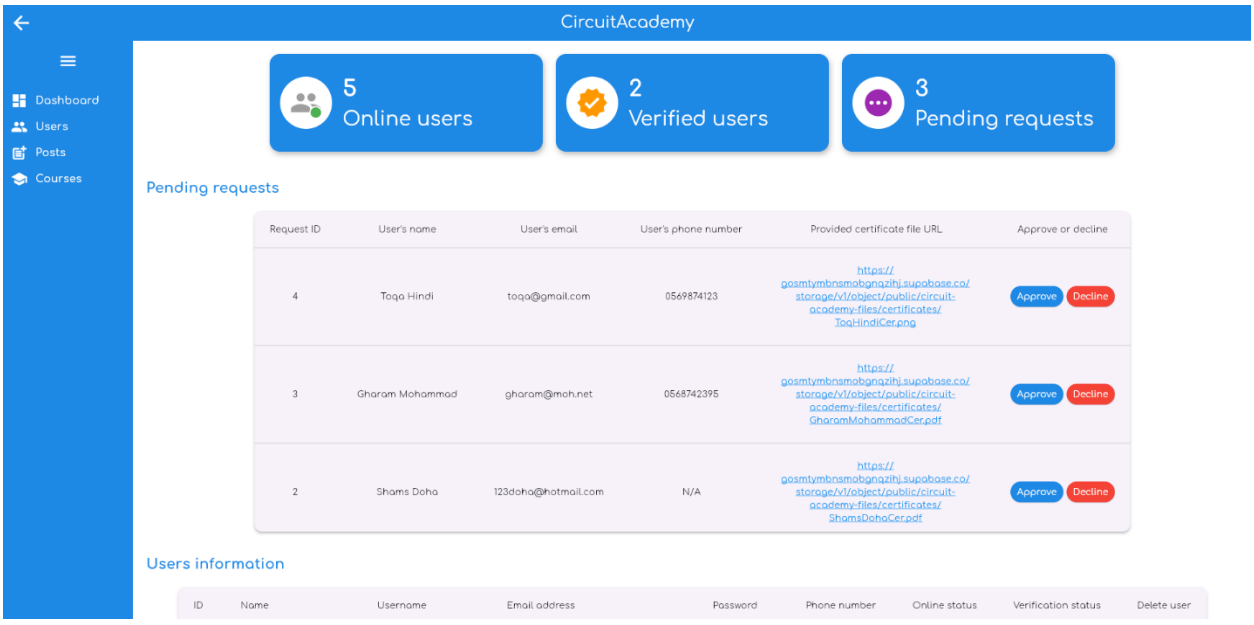


Figure 64: Users page - 1

Figure 65: Users page - 2

- Posts page: Shows information about posts published on the platform.

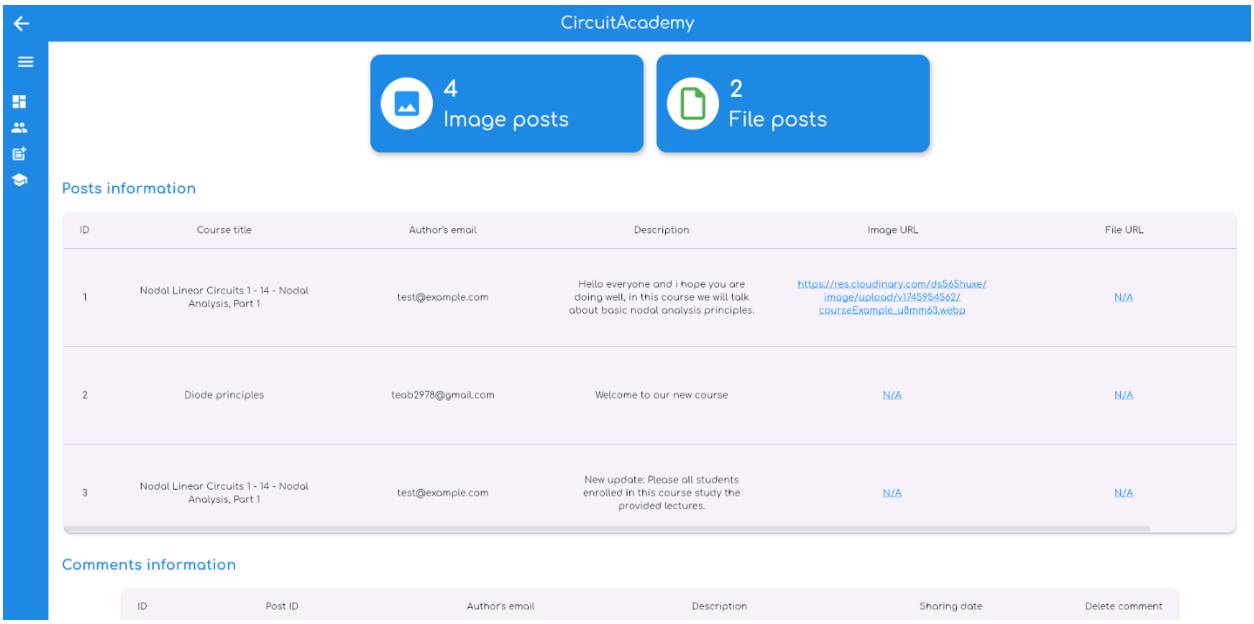


Figure 66: Posts page - 1

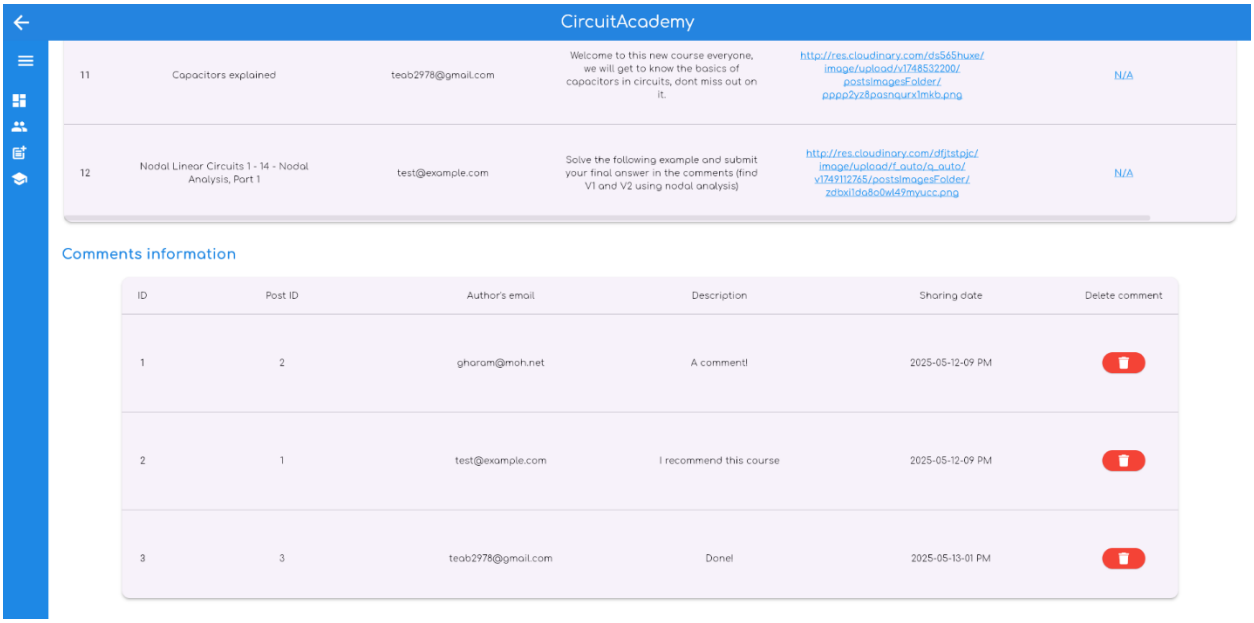


Figure 67: Posts page - 2

- Courses page: Shows information about all courses on the platform

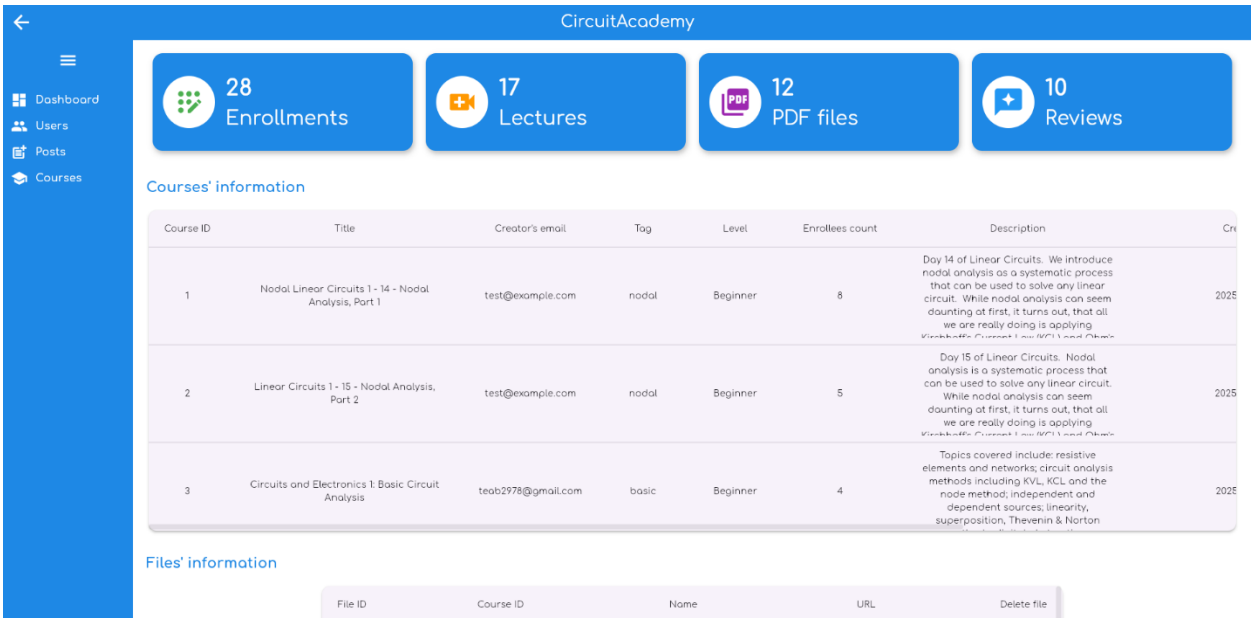


Figure 68: Courses page - 1

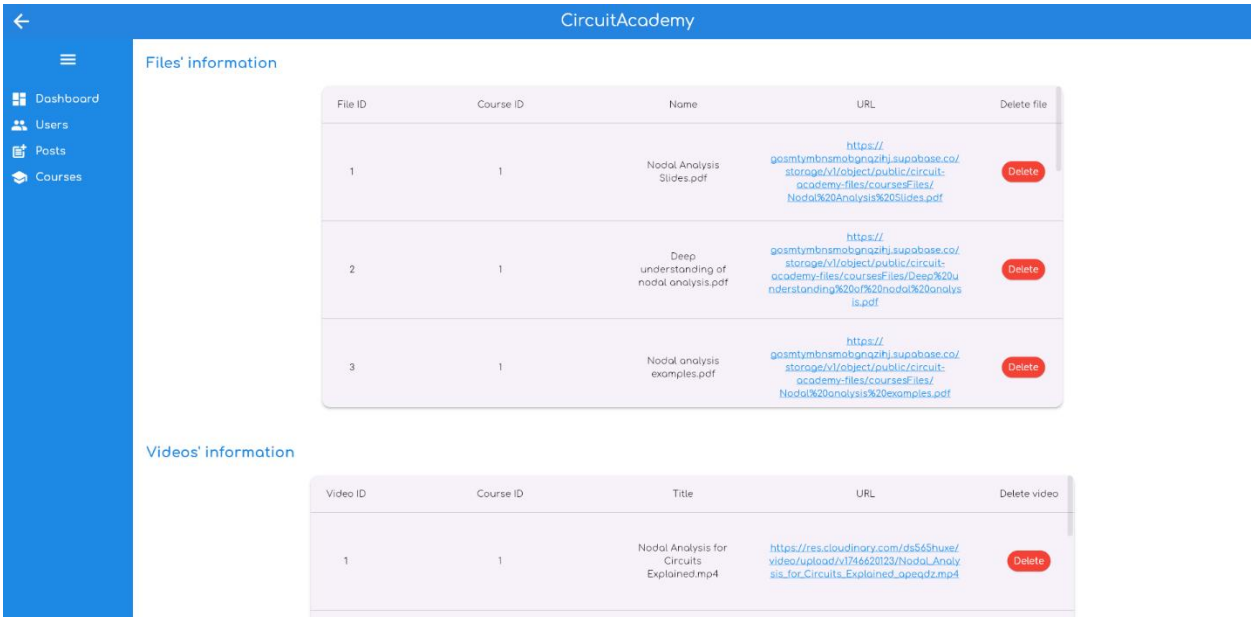


Figure 69: Courses page – 2

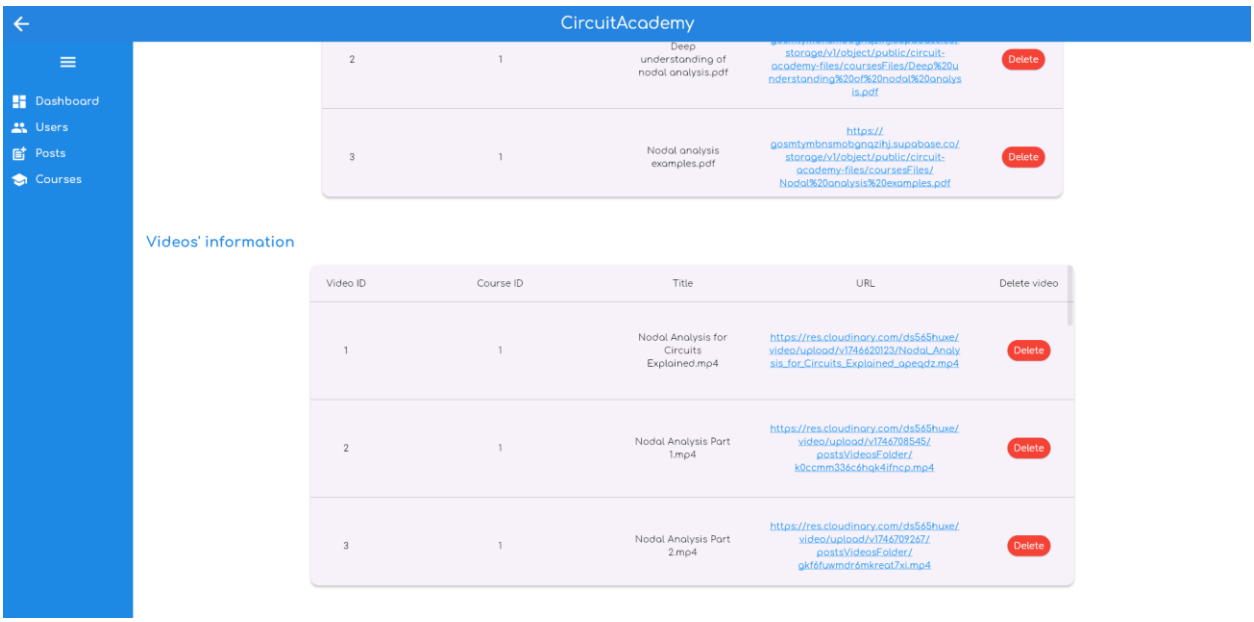


Figure 70: Courses page - 3

- **Feedback messages**

The sent feedback messages and requests are viewed at the end of the dashboard view of the admin panel, it enables the admin to respond to those messages separately by sending emails to users, the following image shows the table of feedback messages and an example of the received email at the user's end.

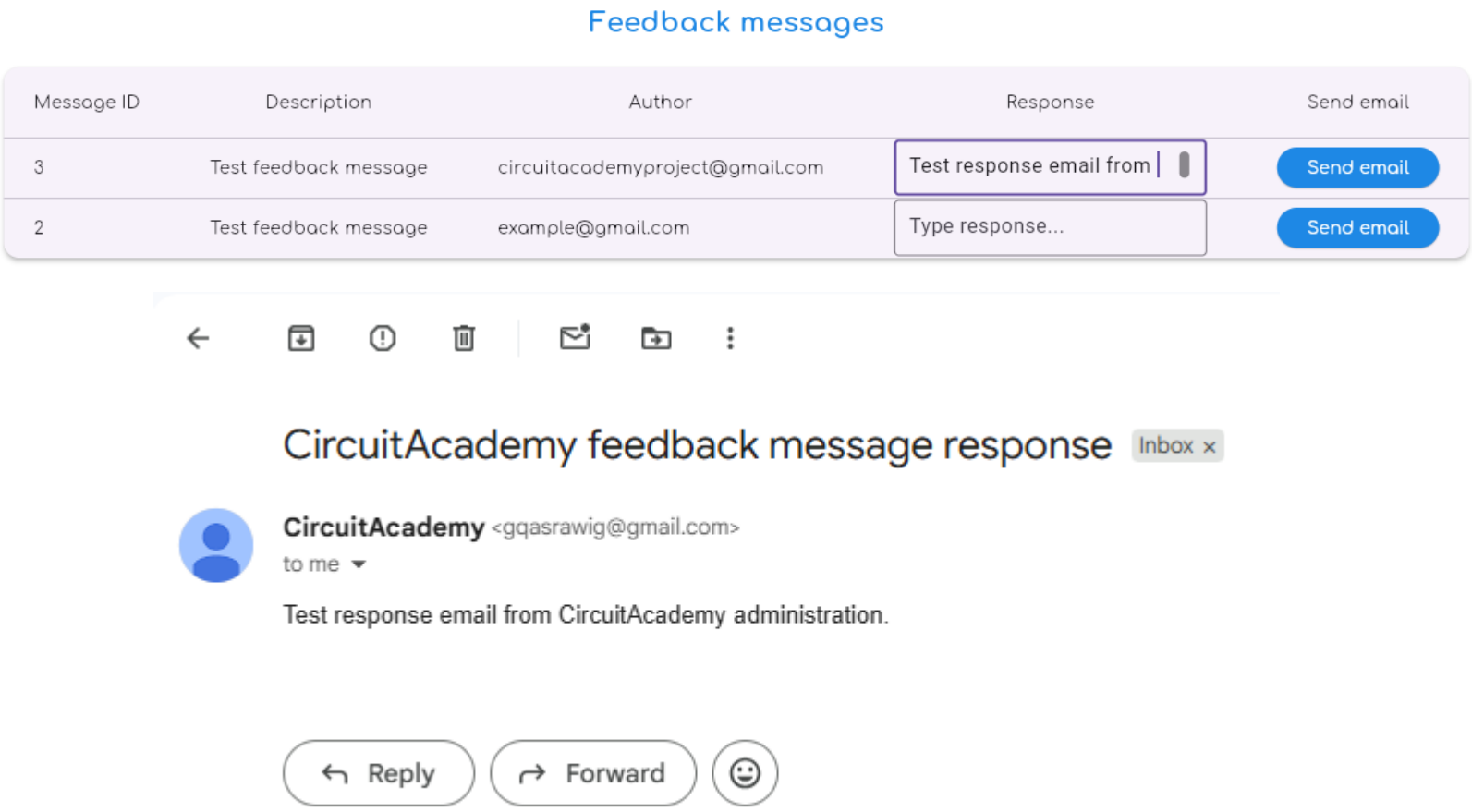


Figure 71: Feedback messages table and sample email

3.3.2 simulation tool

The goal of this simulation tool is to provide students with an interactive way to learn circuit analysis by letting them design circuits, view real-time simulations, and explore step-by-step breakdowns of the underlying equations.

Circuit editor: The circuit editor allows users to build circuits for simulation. The interface is designed to be simple, intuitive, and easy to use, enabling users to quickly create and modify circuits without requiring prior experience.

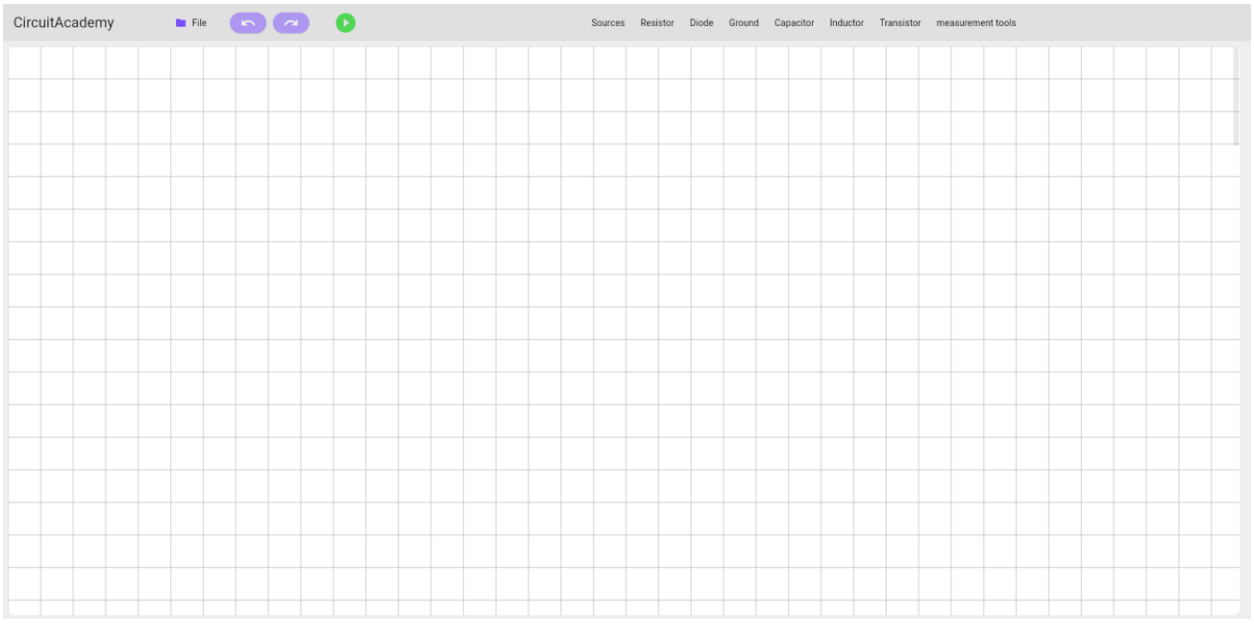


Figure 72: circuit editor

Toolbar:

- **Components**: Users can access the components by clicking on the desired components from the component's menu.

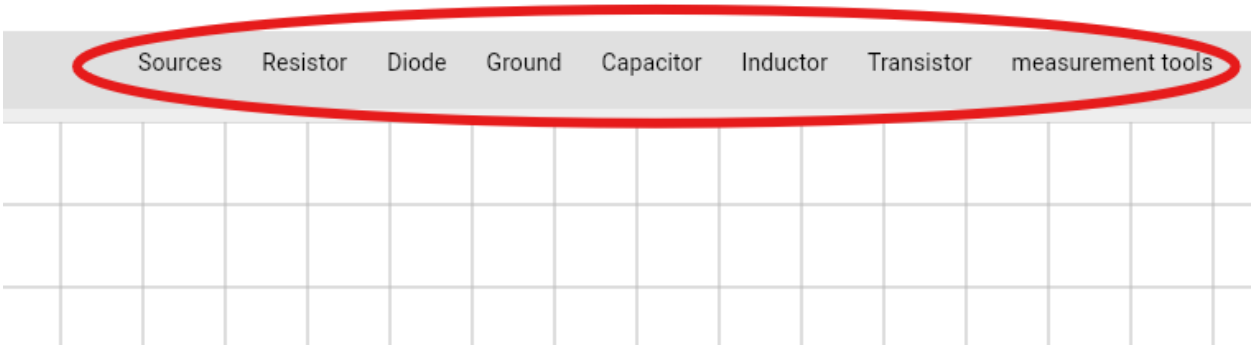


Figure 73: components menu

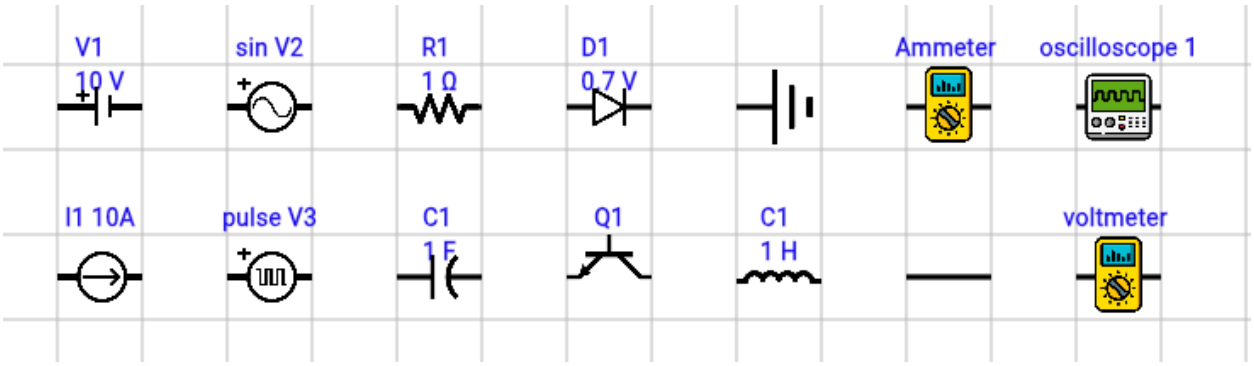


Figure 74: available components and tools

The editor allows users to interact with components by right-clicking them, which opens a menu with options to delete, rotate, change values, or copy. Users can design any circuit they need by dragging components to desired locations and connecting them with wires.

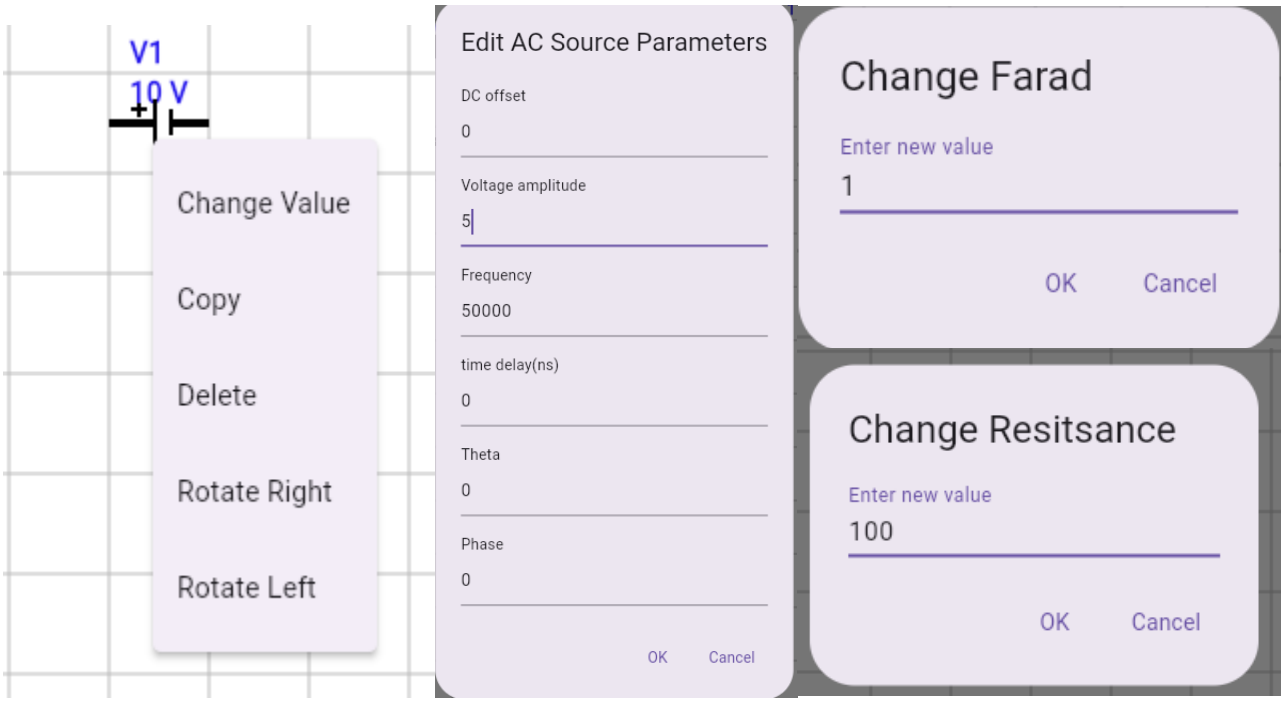


Figure 75: component modification and interaction

- **Redo and undo:** users can undo or redo changes made at anytime by either pressing the buttons in the UI or pressing ctr-z for undo and ctrl-y for redo.

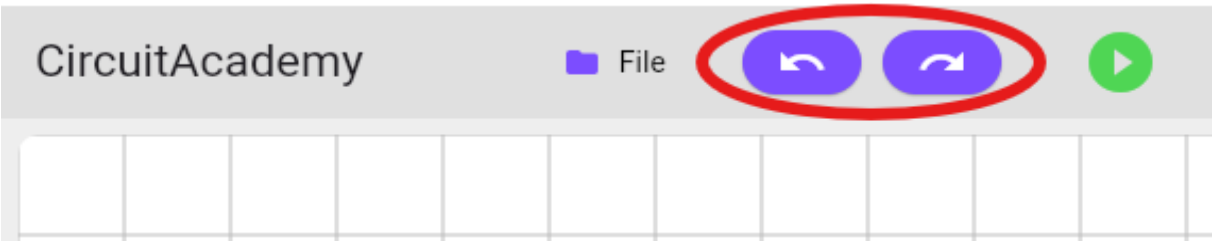


Figure 76: redo and undo

- **File save and load:** users can save the circuits made in a text file which is downloaded onto their device by using the save button, users can also load said circuits from their device by using the load button.

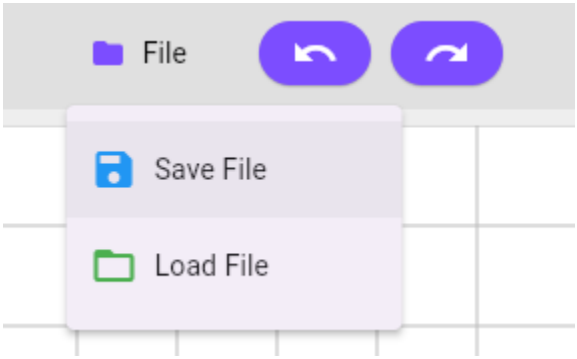


Figure 77: load and save file

- **Start simulation:** once the circuit is built the user can press the start button to begin the simulation and generate the explanation of the circuit.

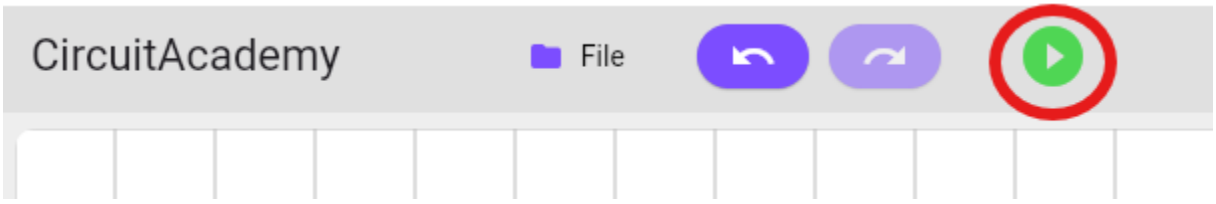


Figure 78: start simulation

Keyboard shortcuts: to increase the QOL of the editor we added shortcuts often used by similar programs.

- **Highlighting:** Users can highlight or unhighlight components by holding ***Shift*** and clicking on individual elements, double-clicking to highlight an entire connected circuit, or pressing ***Shift + A*** to highlight all components currently on the editor.

  Once highlighted, components can be deleted, copied, or moved collectively. Movement can be performed using the ***arrow*** keys or by dragging any highlighted component to the desired location.

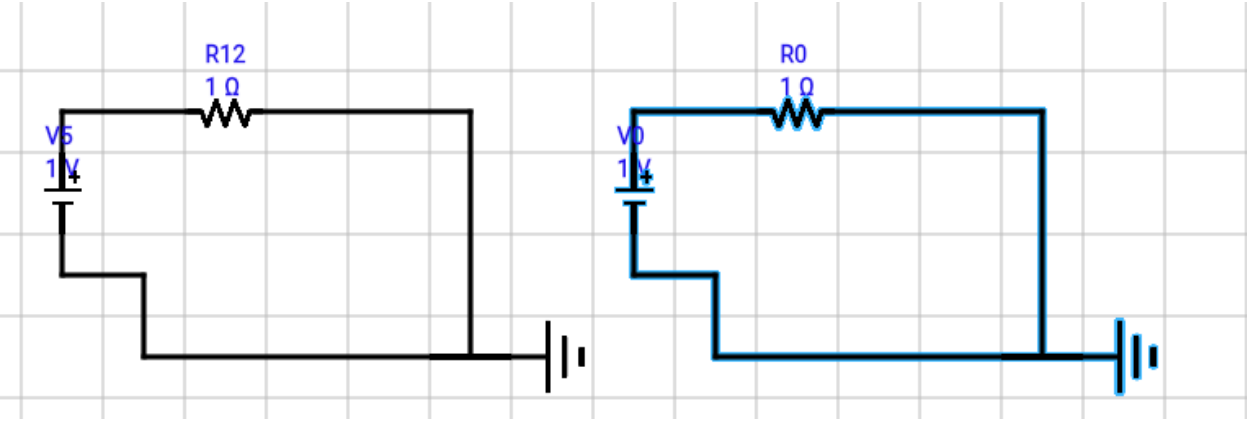


Figure 79: highlighted components

- **Delete:** users can delete highlighted components by pressing the ***delete*** button.
- **Copy:** users can copy highlighted components by pressing ***ctrl + c.***
- **Undo and redo:** Users can undo and redo any changes using **Ctrl + Z** and **Ctrl + Y**, respectively**.**
- **Save:** Users can save the circuits as a file by pressing ***ctrl + S***.
- **Load:** users can load saved circuits by pressing ***ctrl + O*** and choosing the desired file.

Simulation in depth: the simulation works by extracting the netlist from the circuit created by the user and sending it to ngspice to extract the simulation values, once the simulation is over the netlist is sent to a python script which generates the explanation of the formulas used.

Once the user starts the simulation the program will dynamically assign nodes to the circuit to extract the netlist, making sure to assign the ground node as 0.

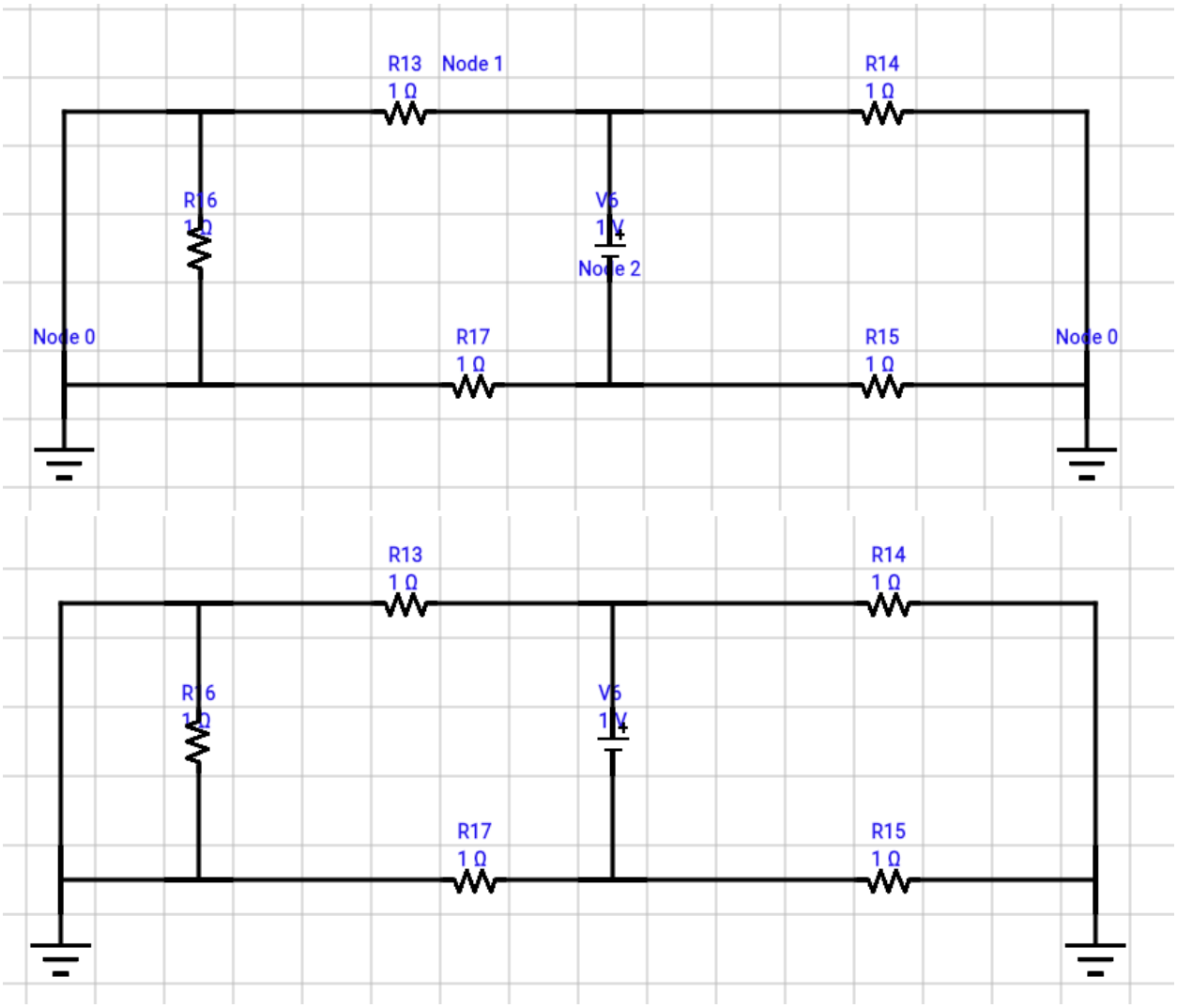


Figure 80: node assignment.

Once the netlist is extracted it is sent to the backend to run the simulation after which the results are displayed on the measurement tools.

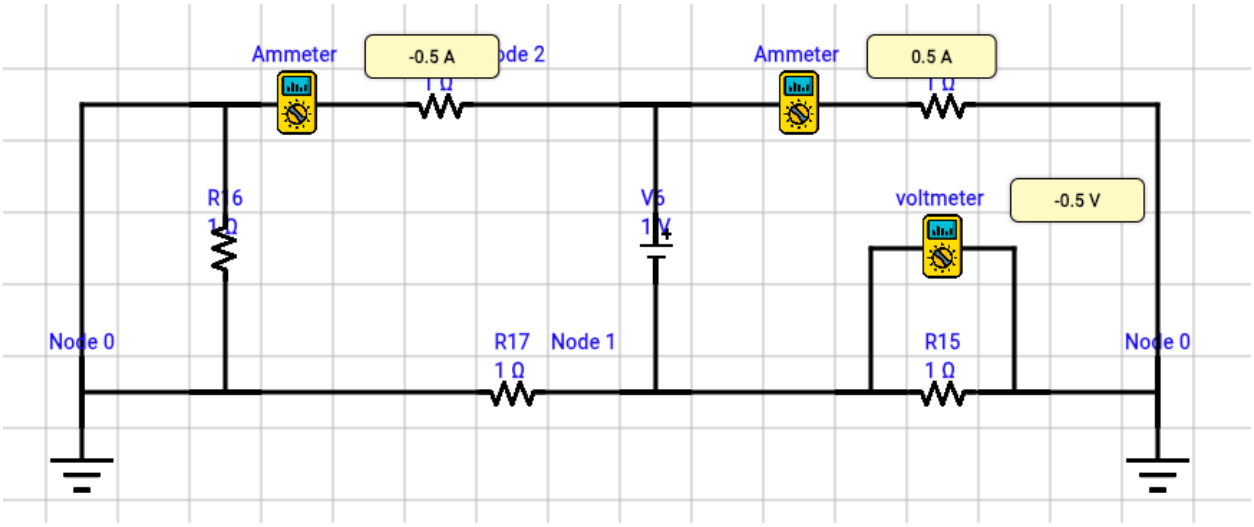
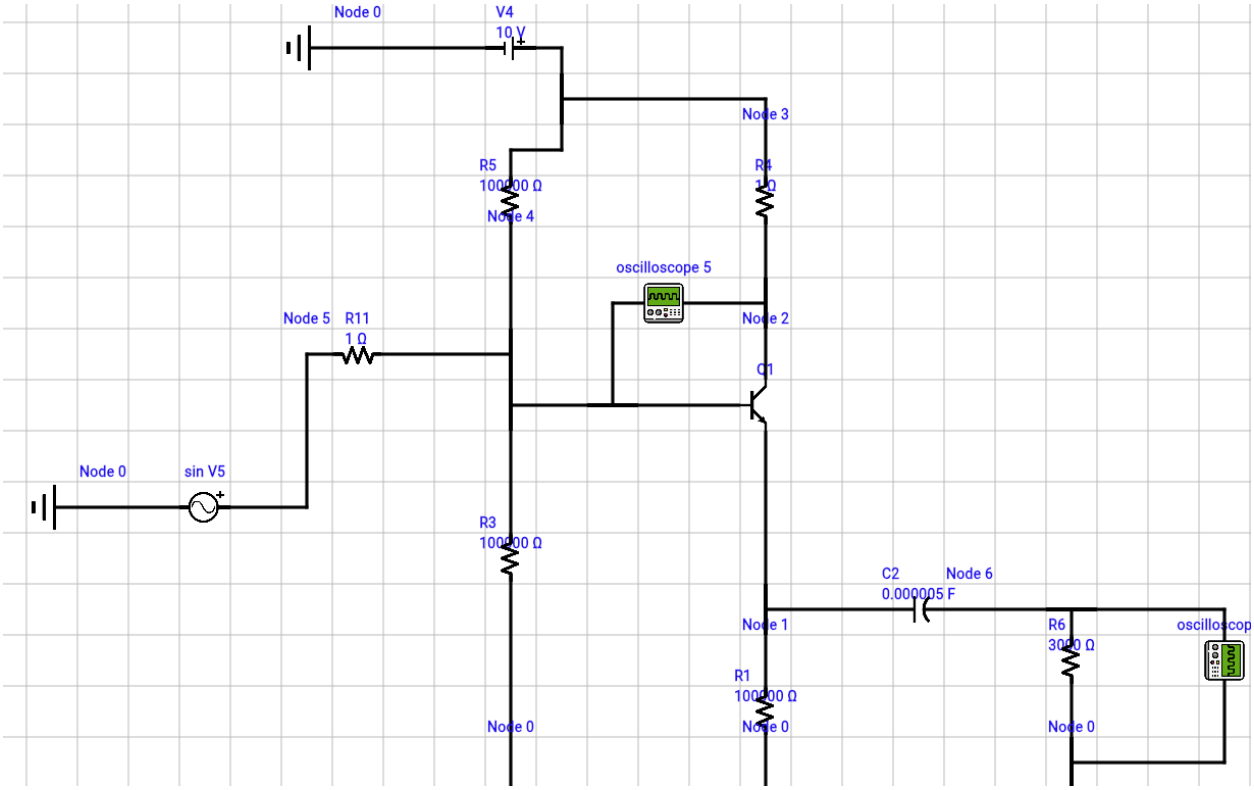


Figure 81: DC simulation results.

When it comes to AC sources transient analysis is required so the oscilloscope tool is used instead of normal voltmeters.



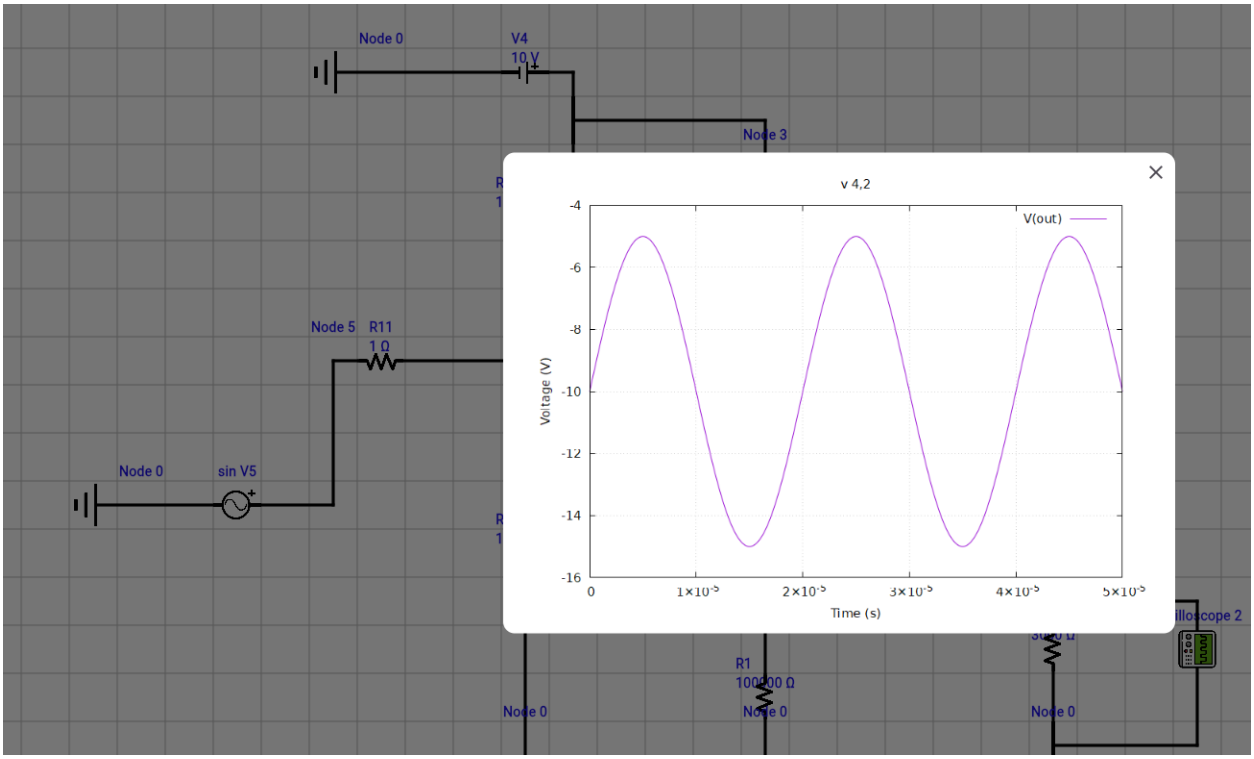


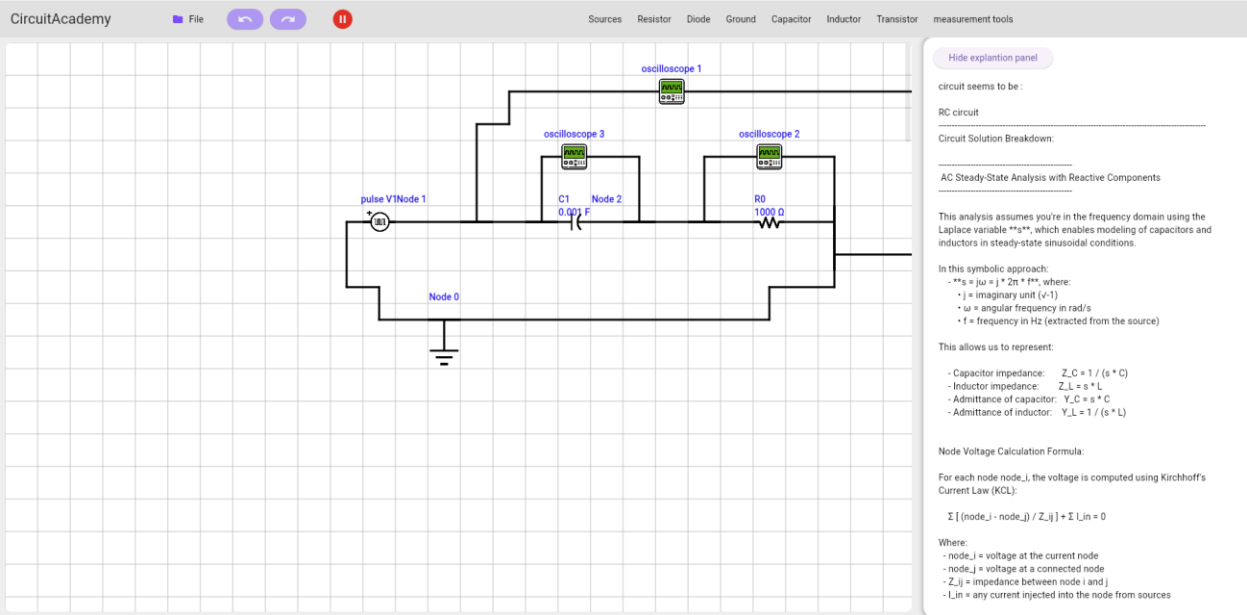
Figure 82: AC simulation results.

to display simulation graphs, Gnuplot was utilized. Each oscilloscope component signals the program to generate a voltage graph between its two connected nodes. A Gnuplot script file is then created automatically, using data extracted from the NGSpice simulation to render the corresponding waveform.

Circuit explanation: The Modified Nodal Analysis (MNA) method is used to symbolically derive the system of equations that governs the behavior of the circuit. This process is implemented using the SymPy library, which enables symbolic manipulation and exact algebraic computation. The conductance matrix, voltage source constraints, and current injections are assembled into a unified matrix equation of the form A·x = z. The solution provides symbolic expressions for all node voltages and source currents, which are then evaluated numerically when component values are available. To enhance educational value, each step of the process is documented in a detailed explanation file, including the full matrix system, the mathematical derivation of each formula, and the calculation of branch currents using Ohm's Law or impedance relations. This allows users not only to observe results, but to understand the reasoning behind them.

The explanations work for both dc analysis and ac analysis but does not support circuits using diodes or transistors.

In addition to providing explanations the netlist is also sent to an API to guess the type of circuit created.



Hide explantion panel

circuit seems to be :

RC circuit

Circuit Solution Breakdown:

AC Steady-State Analysis with Reactive Components

This analysis assumes you're in the frequency domain using the Laplace variable **s**, which enables modeling of capacitors and inductors in steady-state sinusoidal conditions.

In this symbolic approach:
- **s = jω = j * 2π * f**, where:
• j = imaginary unit (√-1)
• ω = angular frequency in rad/s
• f = frequency in Hz (extracted from the source)

This allows us to represent:

- Capacitor impedance: Z_C = 1 / (s * C)
- Inductor impedance: Z_L = s * L
- Admittance of capacitor: Y_C = s * C
- Admittance of inductor: Y_L = 1 / (s * L)

Node Voltage Calculation Formula:

For each node node_i, the voltage is computed using Kirchhoff's Current Law (KCL):

Σ [(node_i - node_j) / Z_ij] + Σ I_in = 0

Where:
- node_i = voltage at the current node
- node_j = voltage at a connected node
- Z_ij = impedance between node i and j
- I_in = any current injected into the node from sources

Matrix System :
A * x = z

A matrix (coefficients):
[C1*s -C1*s -1]
[-C1*s C1*s + 1/R0 0]
[-1 0 0]

x vector (unknowns):
[node_1]
[node_2]
[I_V1]

z vector (sources):
[0]
[0]
[V1]

node_1 = -V1 = -V1
node_2 = -C1*R0*V1*s/(C1*R0*s + 1) = -100000.0*I*pi*V1/(1 + 100000.0*I*pi)
I_V1 = -C1*V1*s/(C1*R0*s + 1) = -100.0*I*pi*V1/(1 + 100000.0*I*pi)

Branch Current Calculation (Ohm's Law):

After solving the Modified Nodal Analysis system, we calculate the current through each passive component using Ohm's Law:

I = (V_node1 - V_node2) / R

Where:
- I is the current through the component
- V_node1 and V_node2 are the voltages at the component's terminals
- R is the resistance (or impedance for reactive components)

This applies to:
- Resistors: I_R = (V1 - V2) / R
- Capacitors/Inductors (in AC): use reactance (X) instead of resistance (R)

Figure 83: explanation results.

3.3.3 Mobile application

Note: The figures for the mobile application were captured using a mobile android emulator (Pixel_7_Pro_API_35:5554)

- **Welcome page:** Enables users to sign in to the platform via different methods, email & password, Gmail account, Outlook account, or GitHub account. It also allows users to register and recover their accounts.

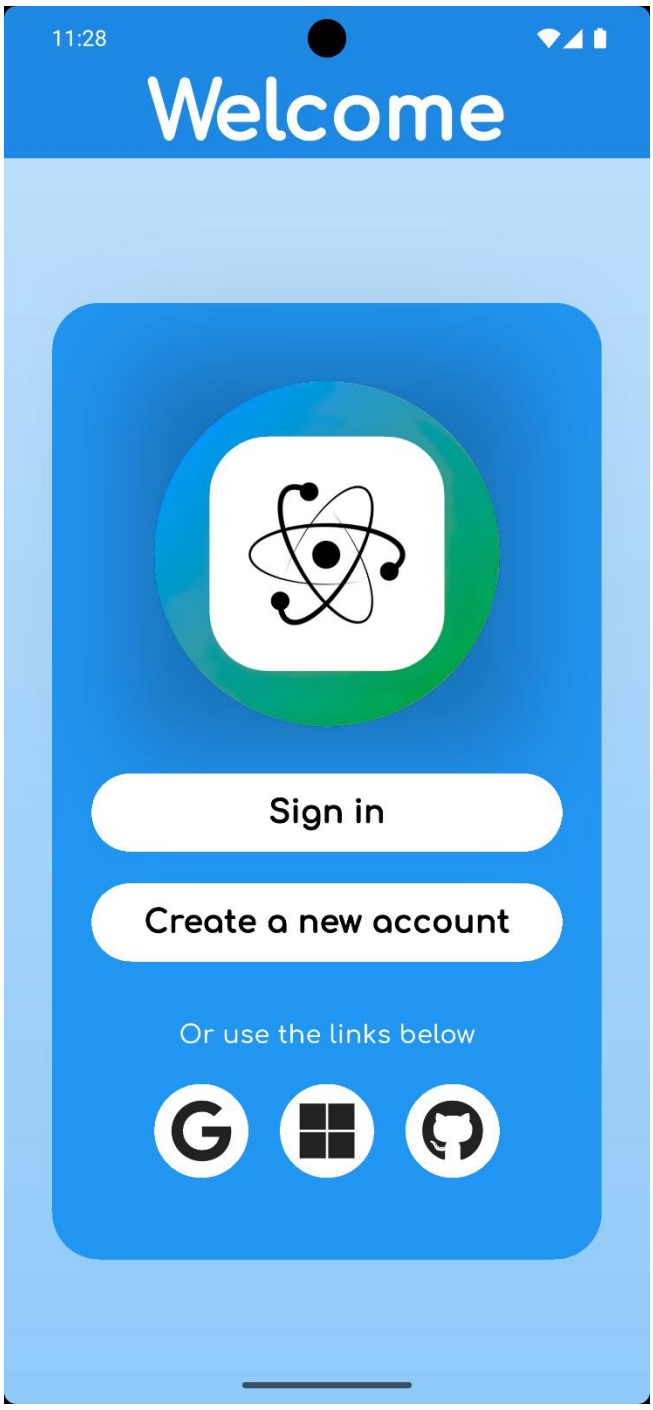


Figure 84: Mobile welcome page

- **Sign in page**

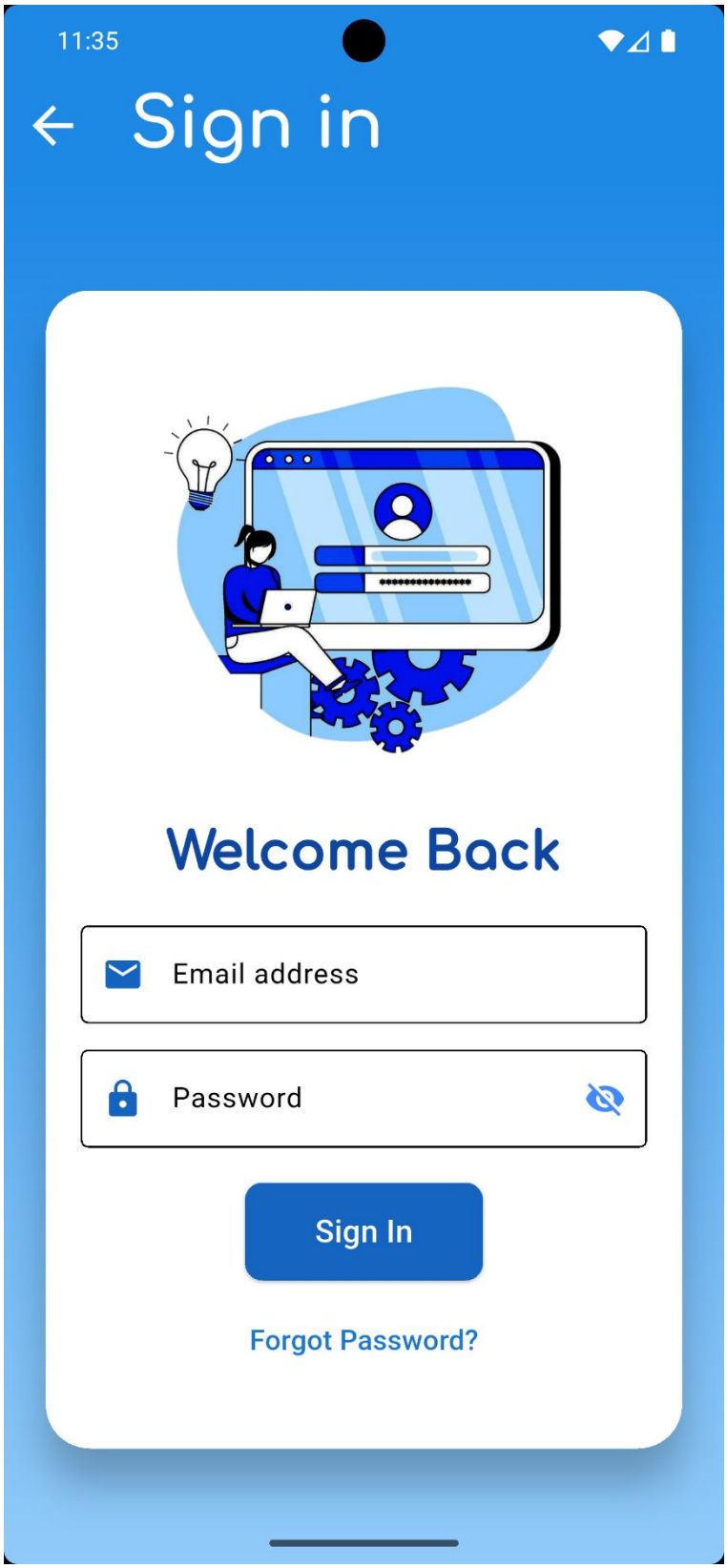


Figure 85: Mobile sign in page

- Password recovery page

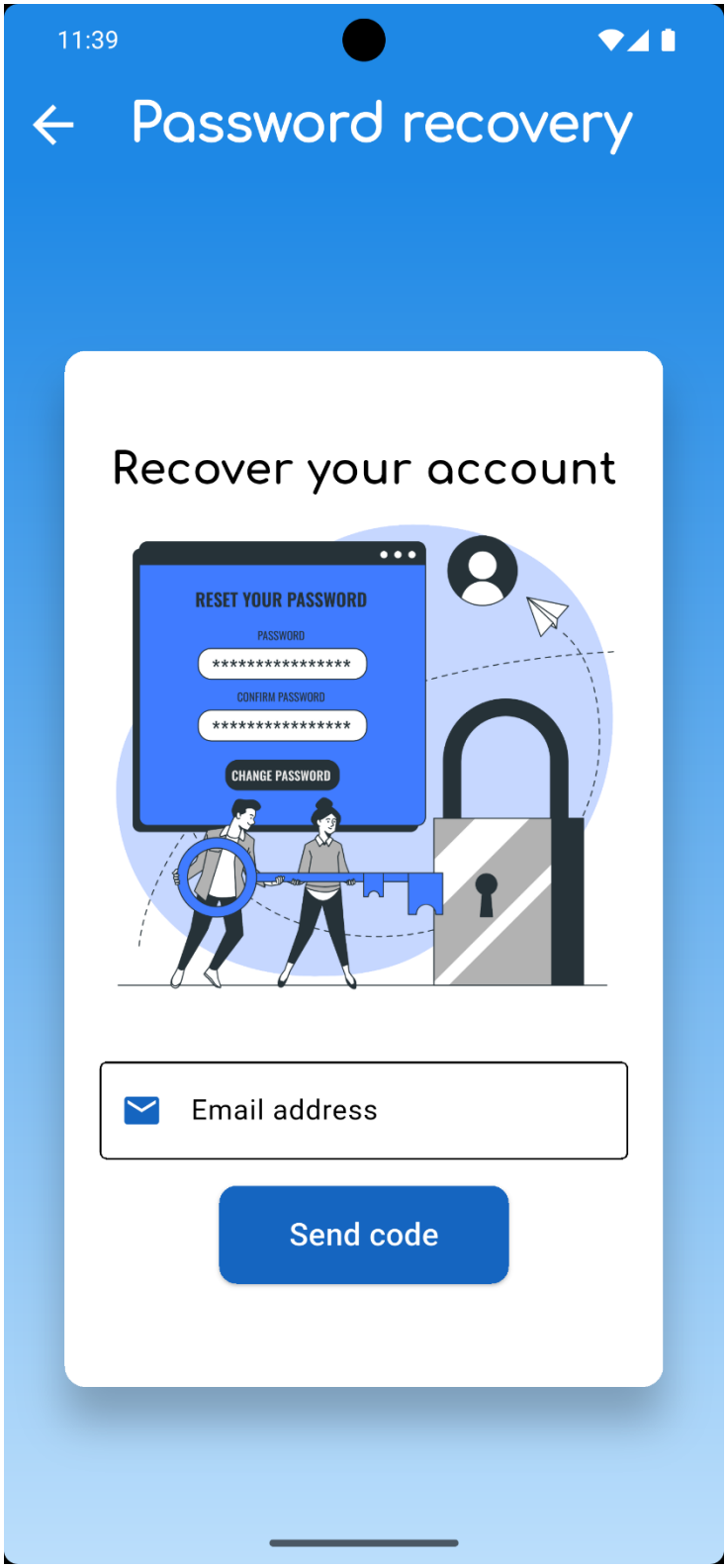


Figure 86: Mobile password recovery page

- **Home page:** Shows community groups after choosing a previously enrolled course from the drawer.

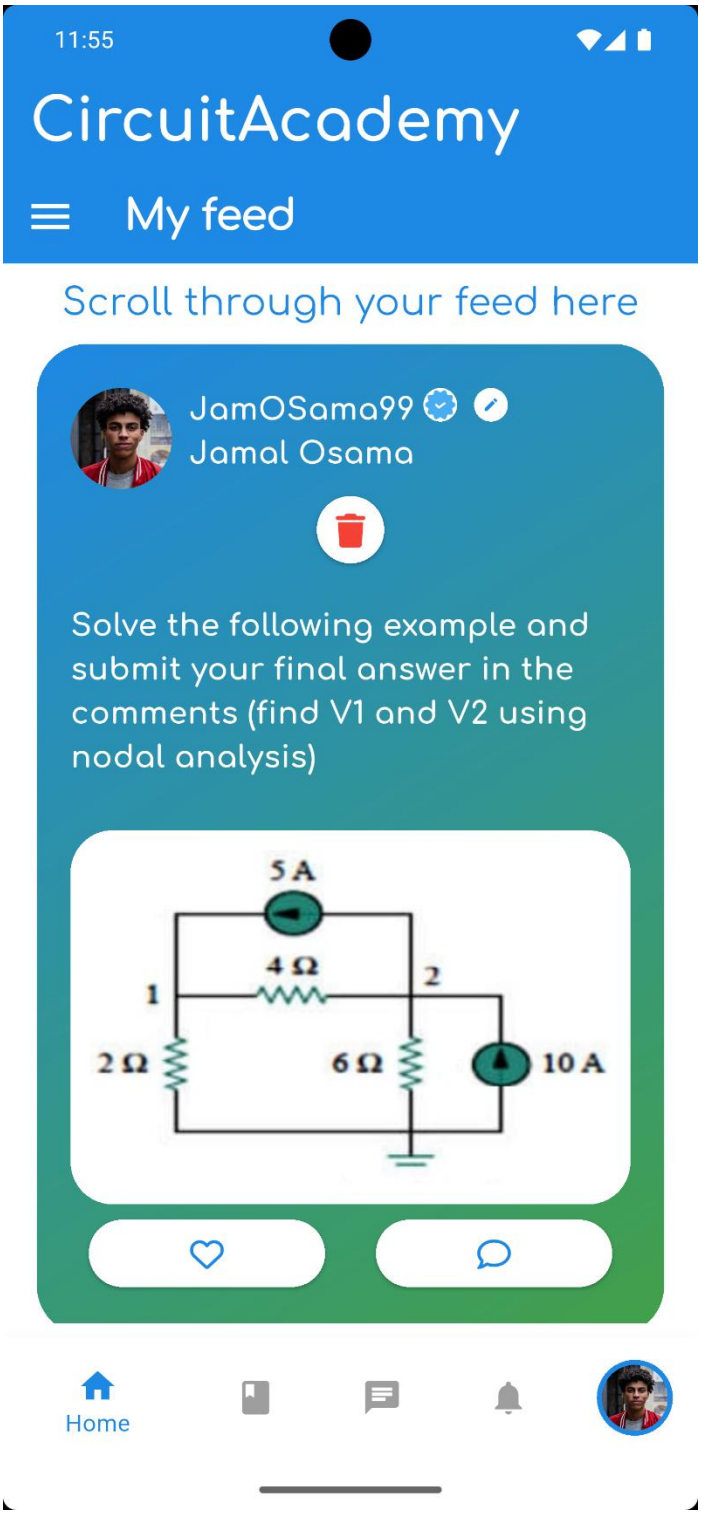


Figure 87: Mobile home page

The list enables users to create a post or change the current feed view based on enrolled courses

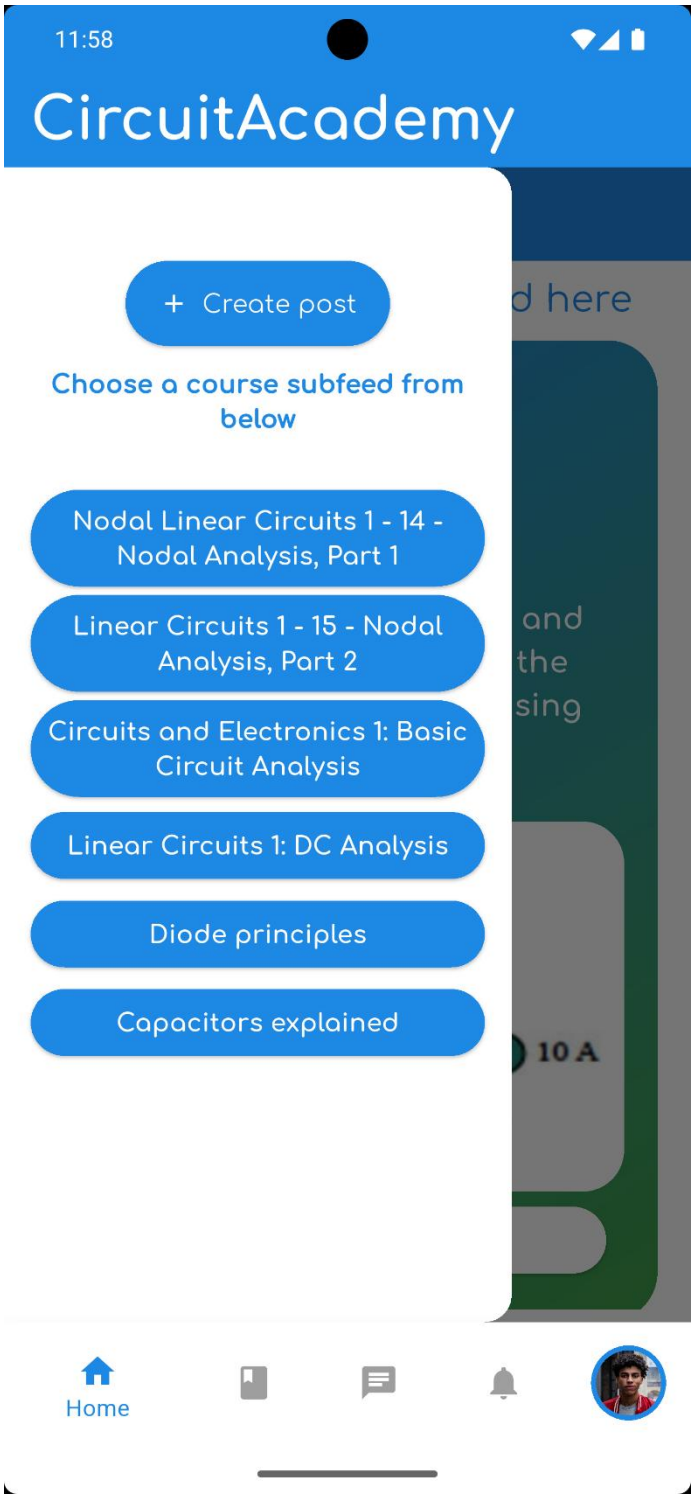


Figure 88: Mobile home page drawer

- **Courses page:** Allows users to navigate through courses, check details of each course, update them or create new ones.

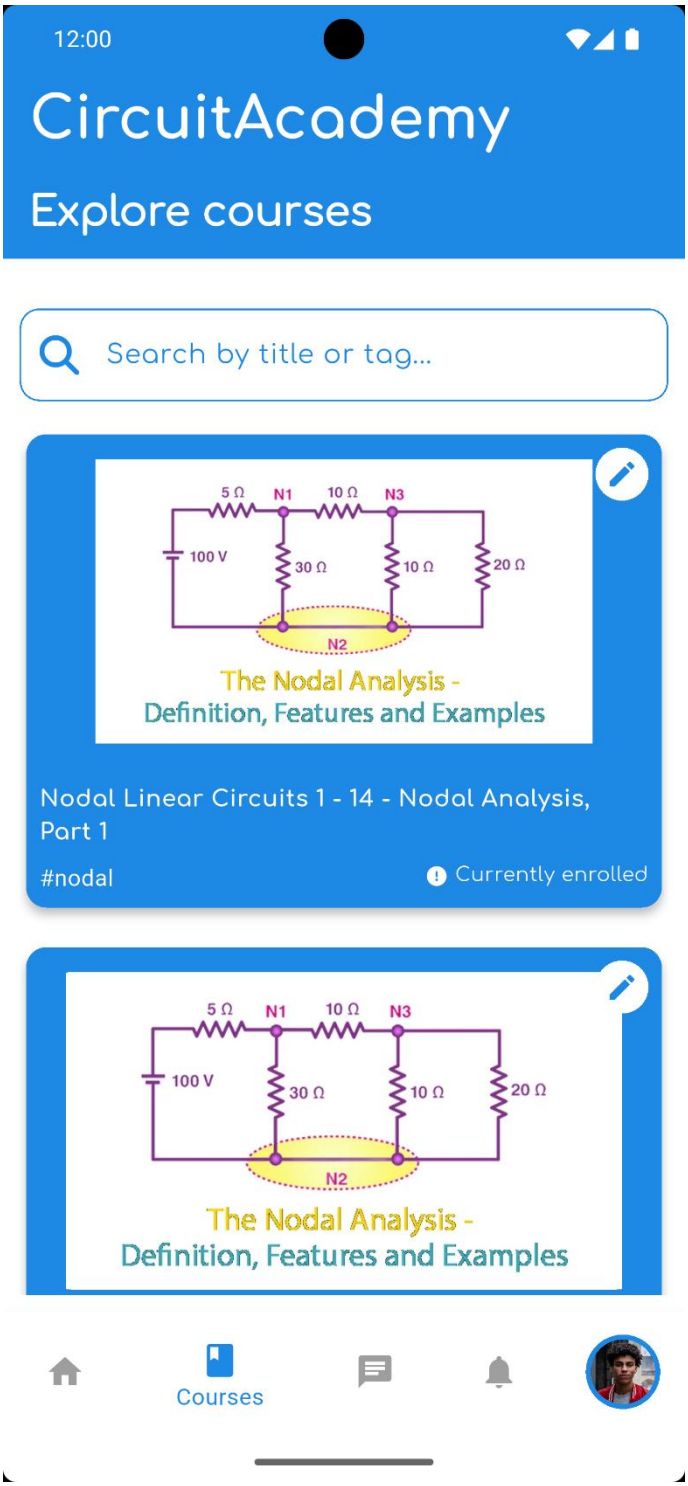


Figure 90: Mobile courses page - 1

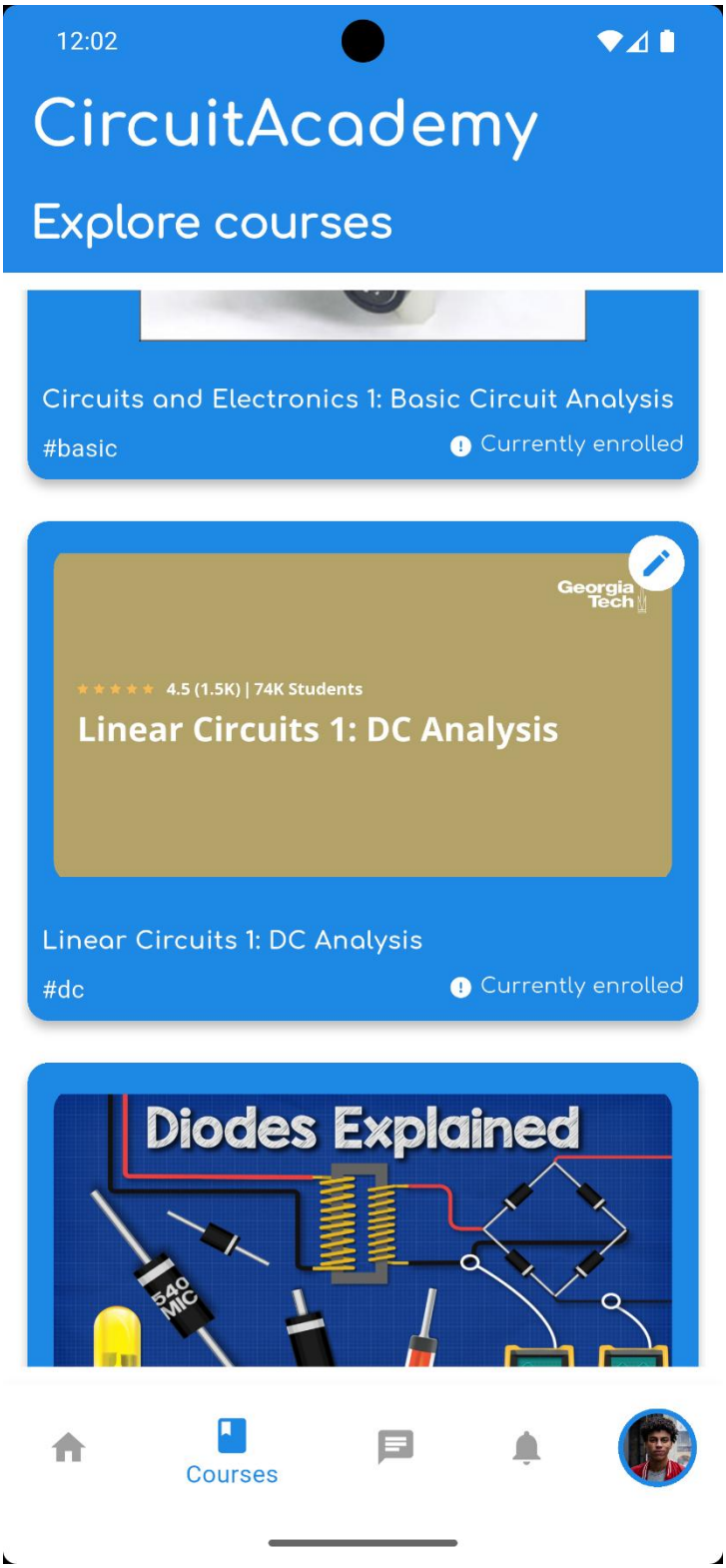


Figure 89: Mobile courses page - 2

Clicking on a course brings its details, content and reviews

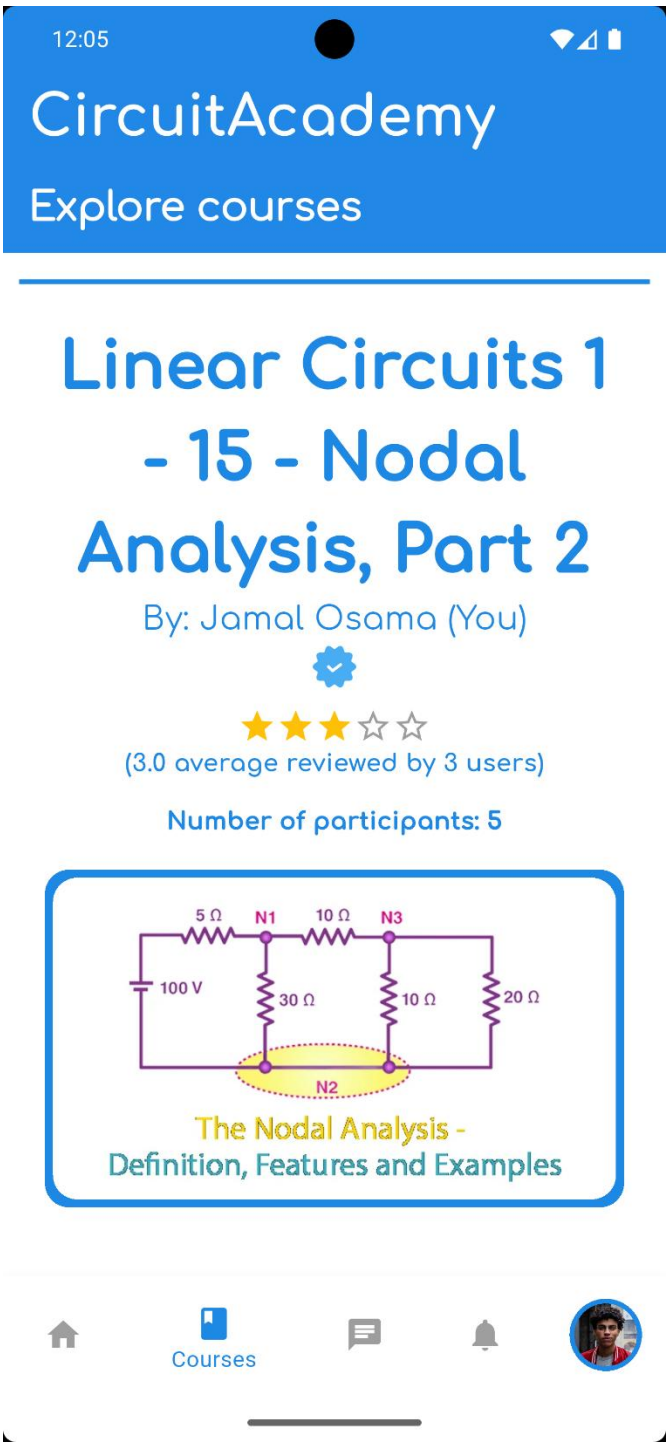


Figure 92: Mobile course details - 1

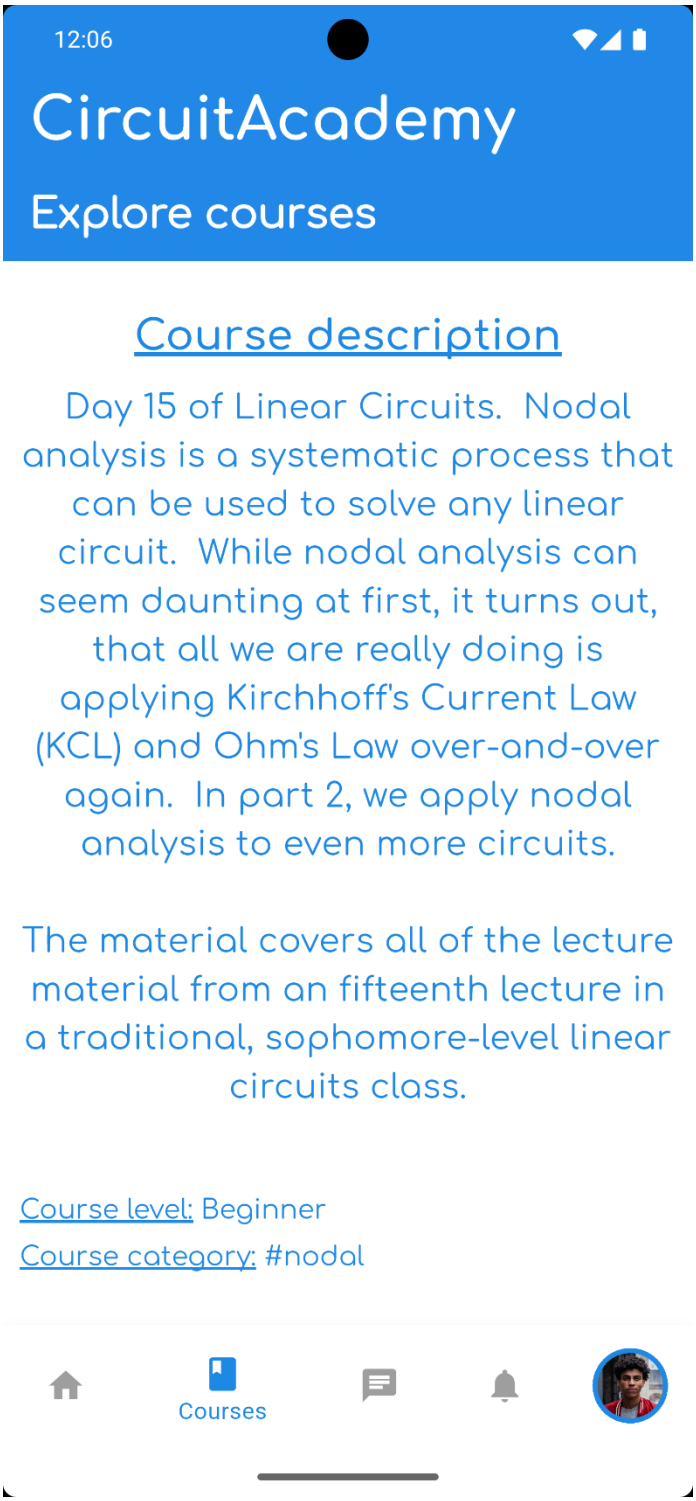


Figure 91 : Mobile course details - 2

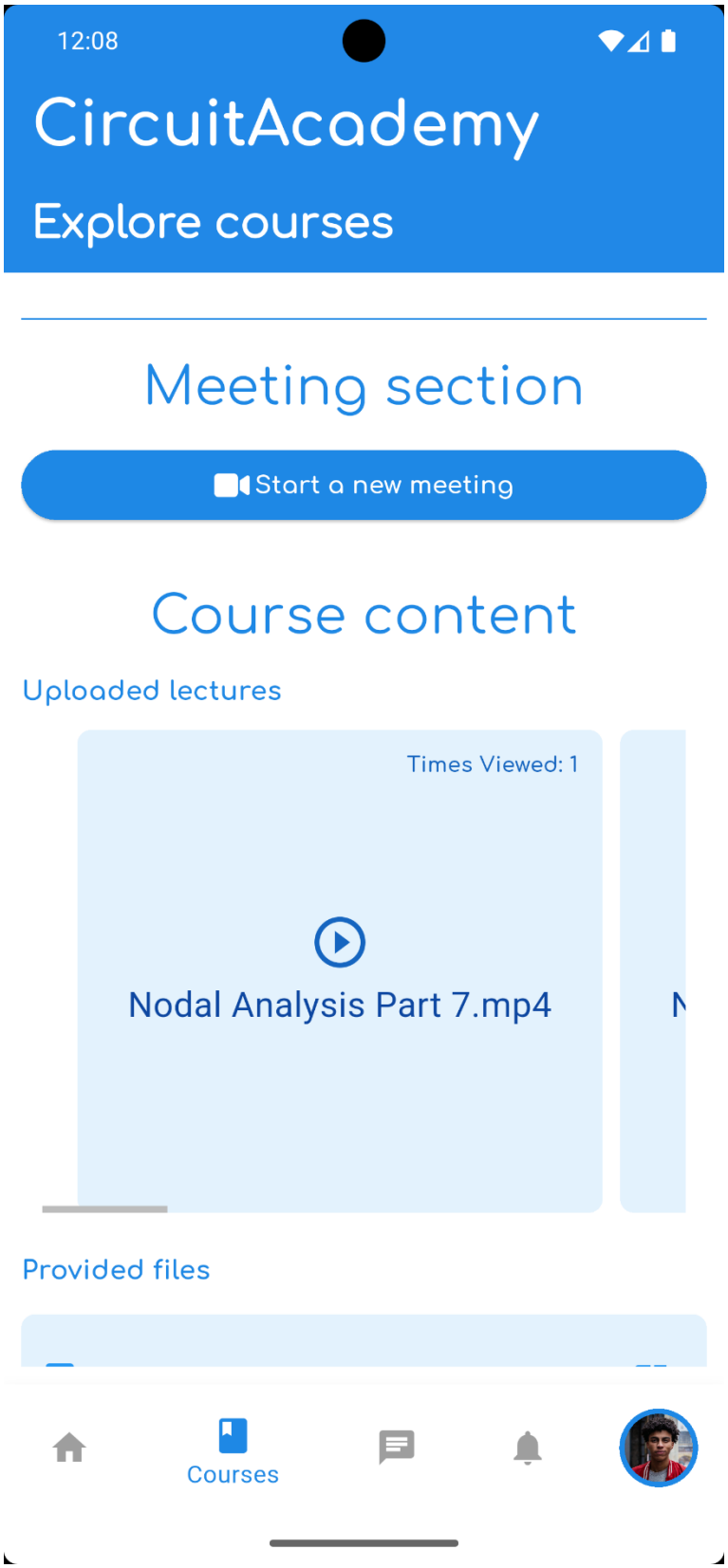


Figure 94: Mobile course details - 3

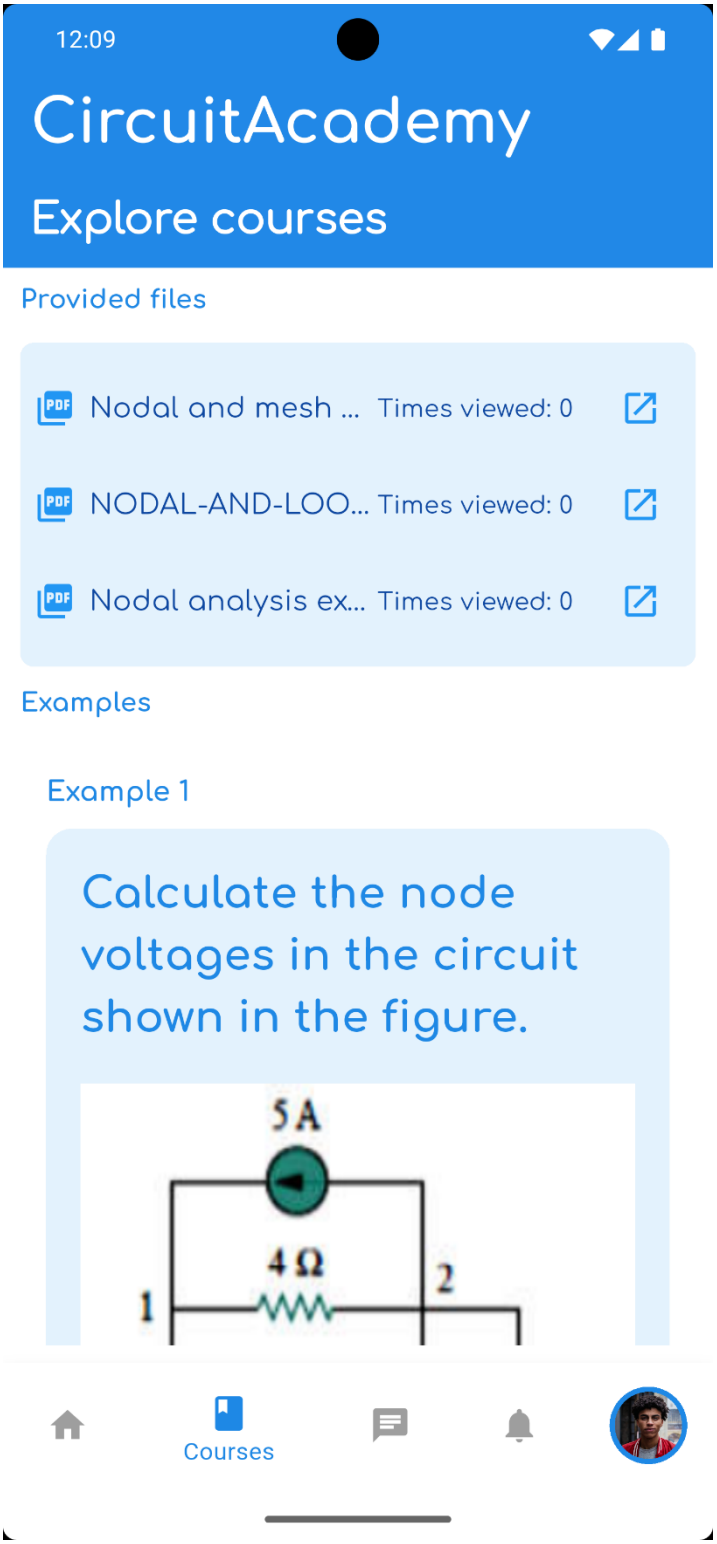


Figure 93: Mobile course section details - 4

Clicking check in simulator opens the example in the simulator page on an external browser.

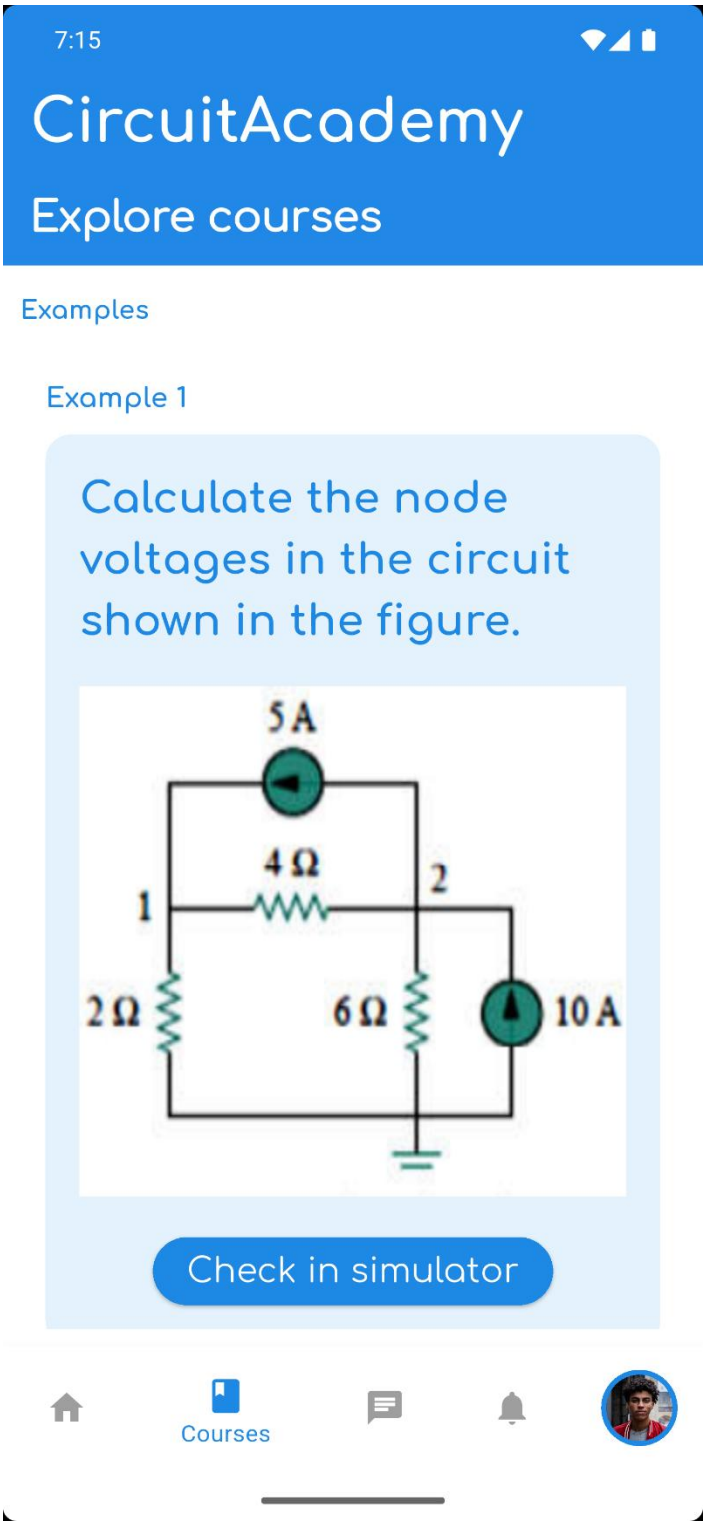


Figure 96: Mobile course details - 5

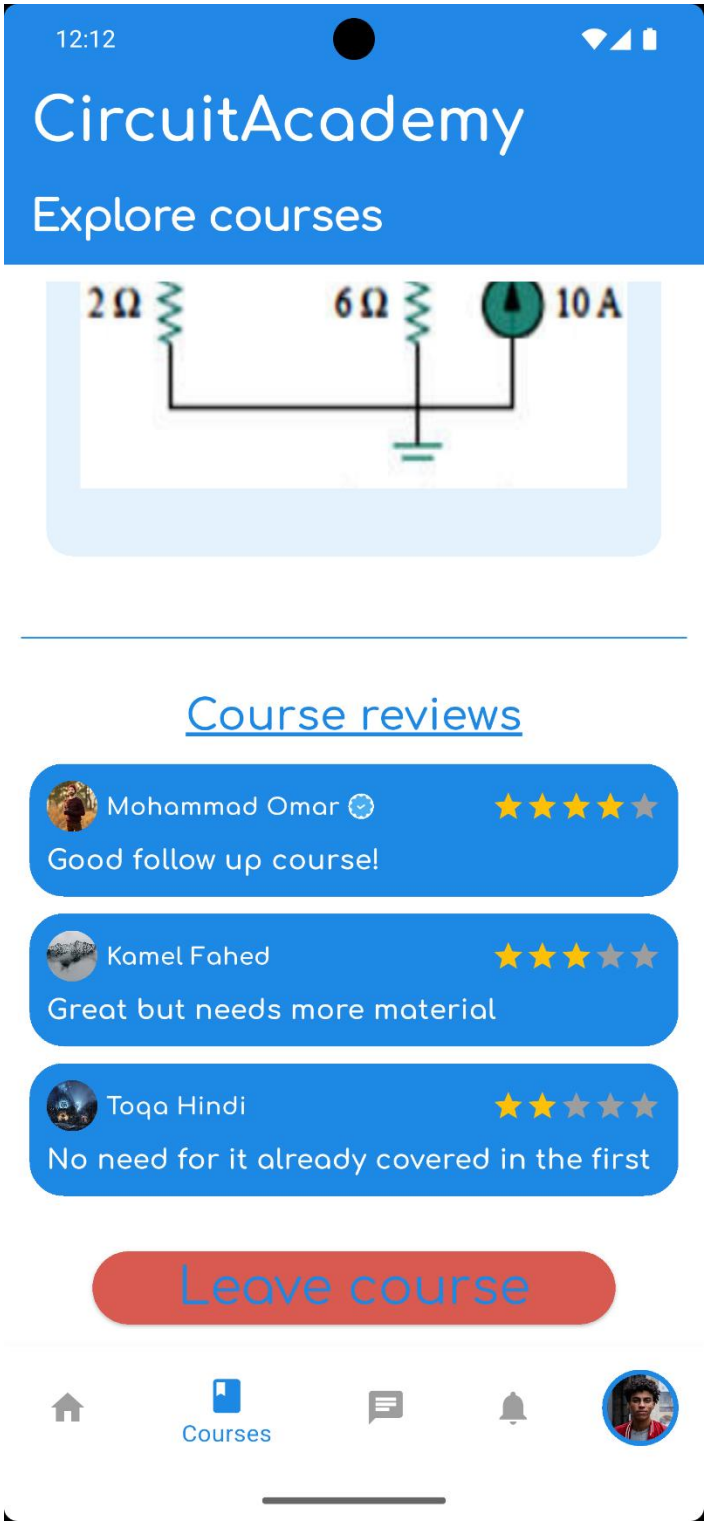


Figure95: Mobile course details - 6

- **Meeting screen**

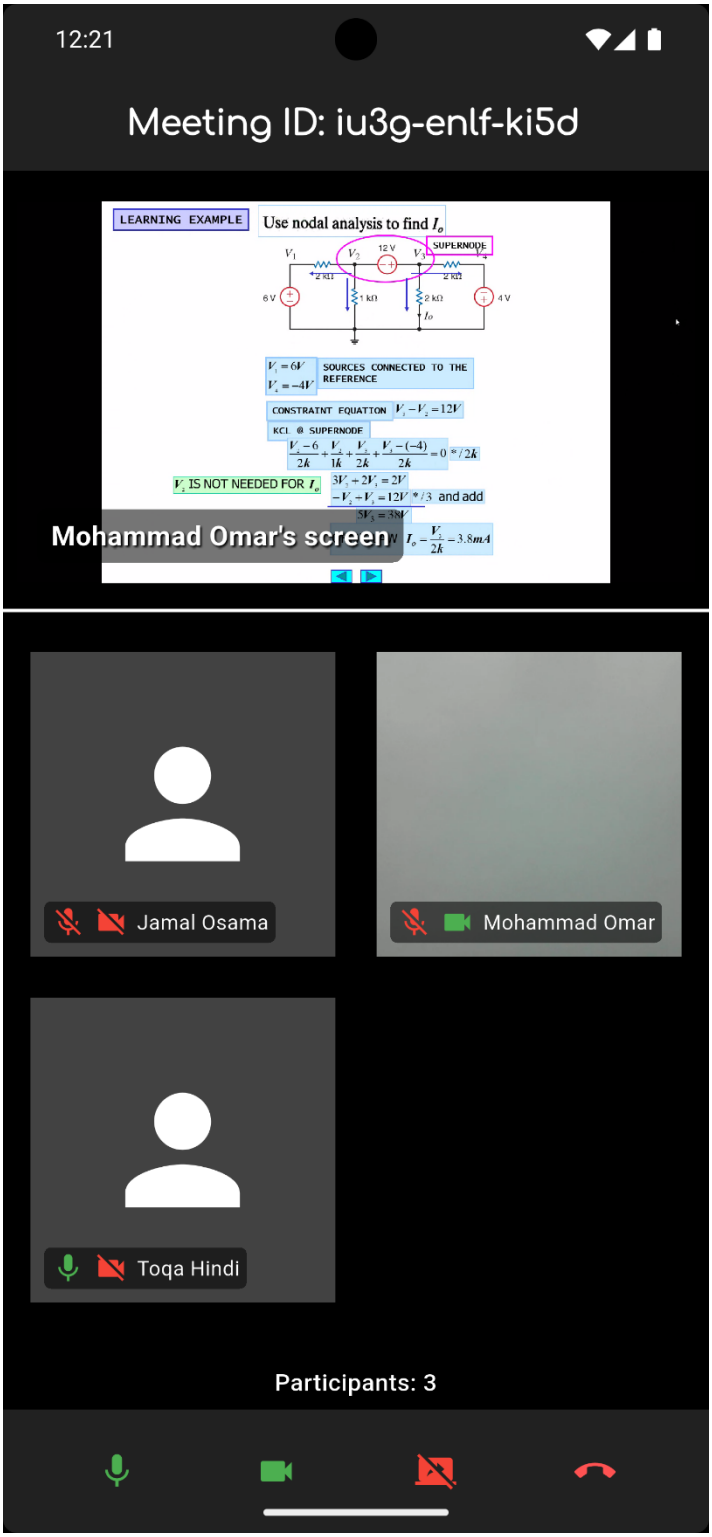


Figure 97: Mobile meeting

- **Lectures and files viewing**: uploaded files are opened in an external browser while the lectures can be shown directly.

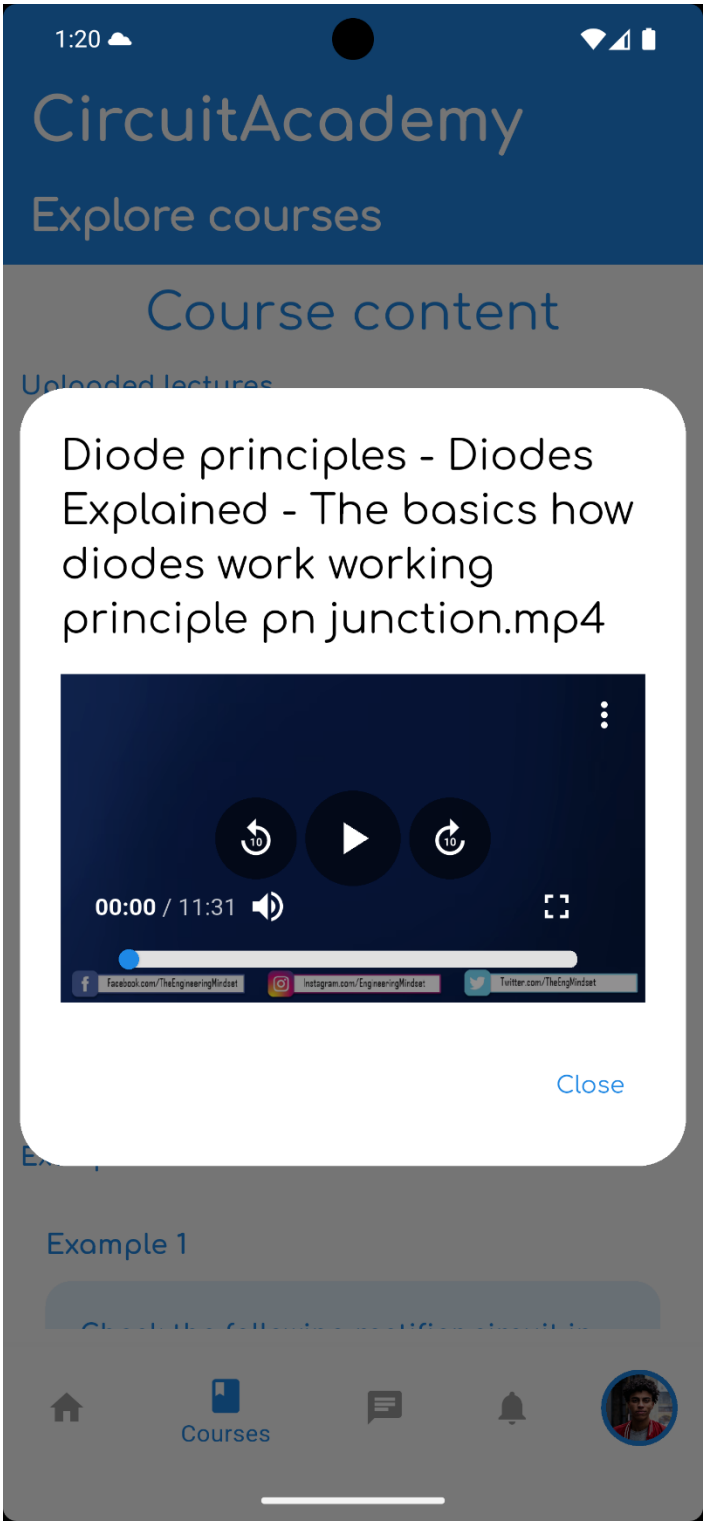


Figure 98: Mobile lecture viewing

Clicking the full screen option opens the video in full screen after rotating the view.

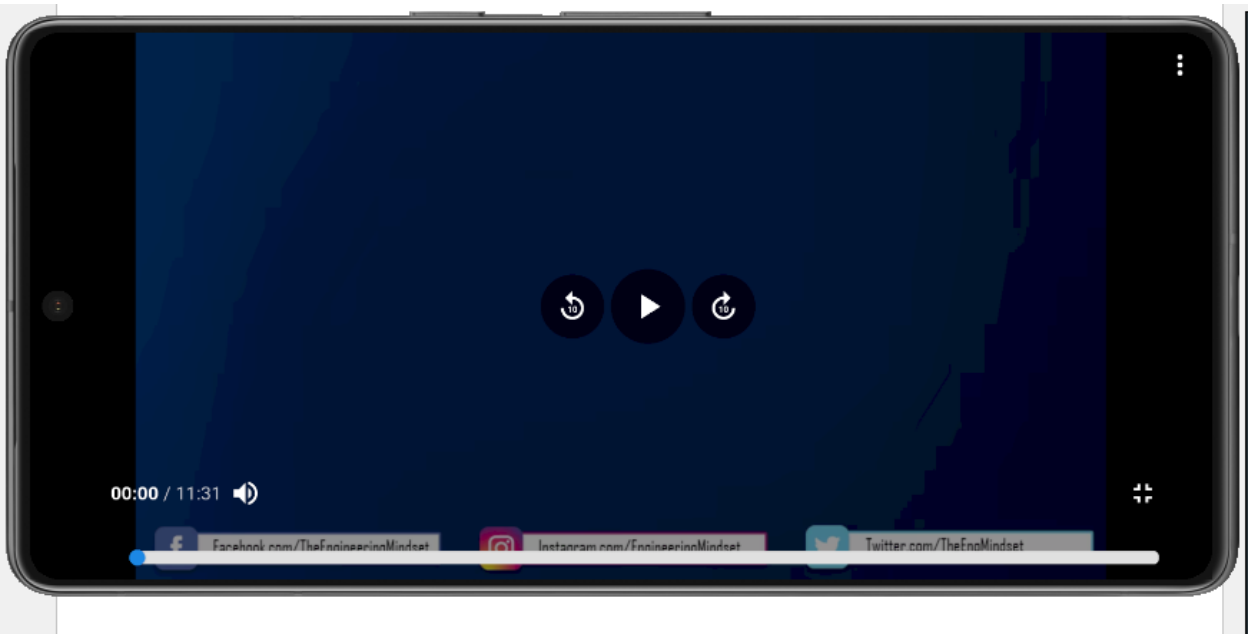


Figure 99: Mobile full screen lecture view

- **Chat page**: A list of enrolled courses appears to the user to choose, which shows enrolled students afterwards.

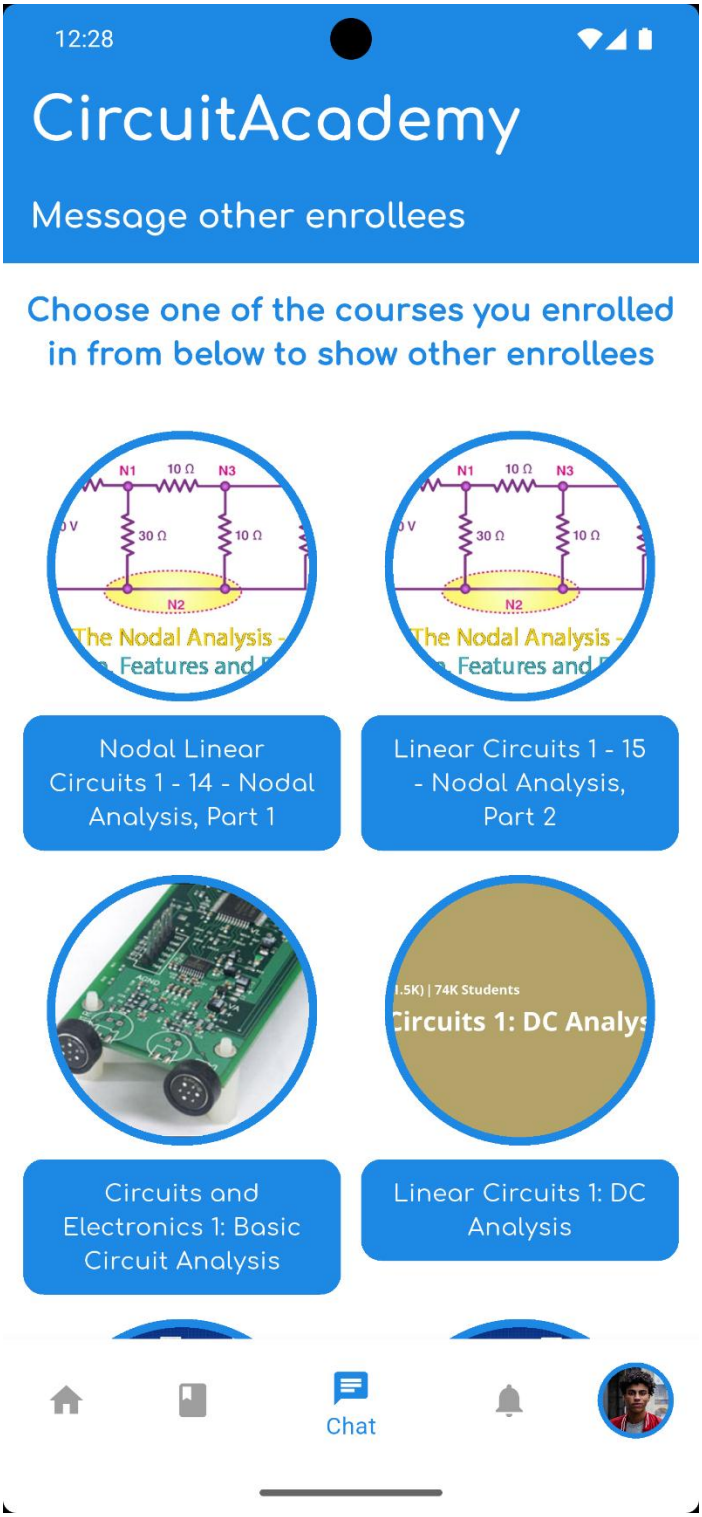


Figure 100: Mobile chat page

If the user selects the second course for example, chat page shows the following image. Also online users will appear first in the list.

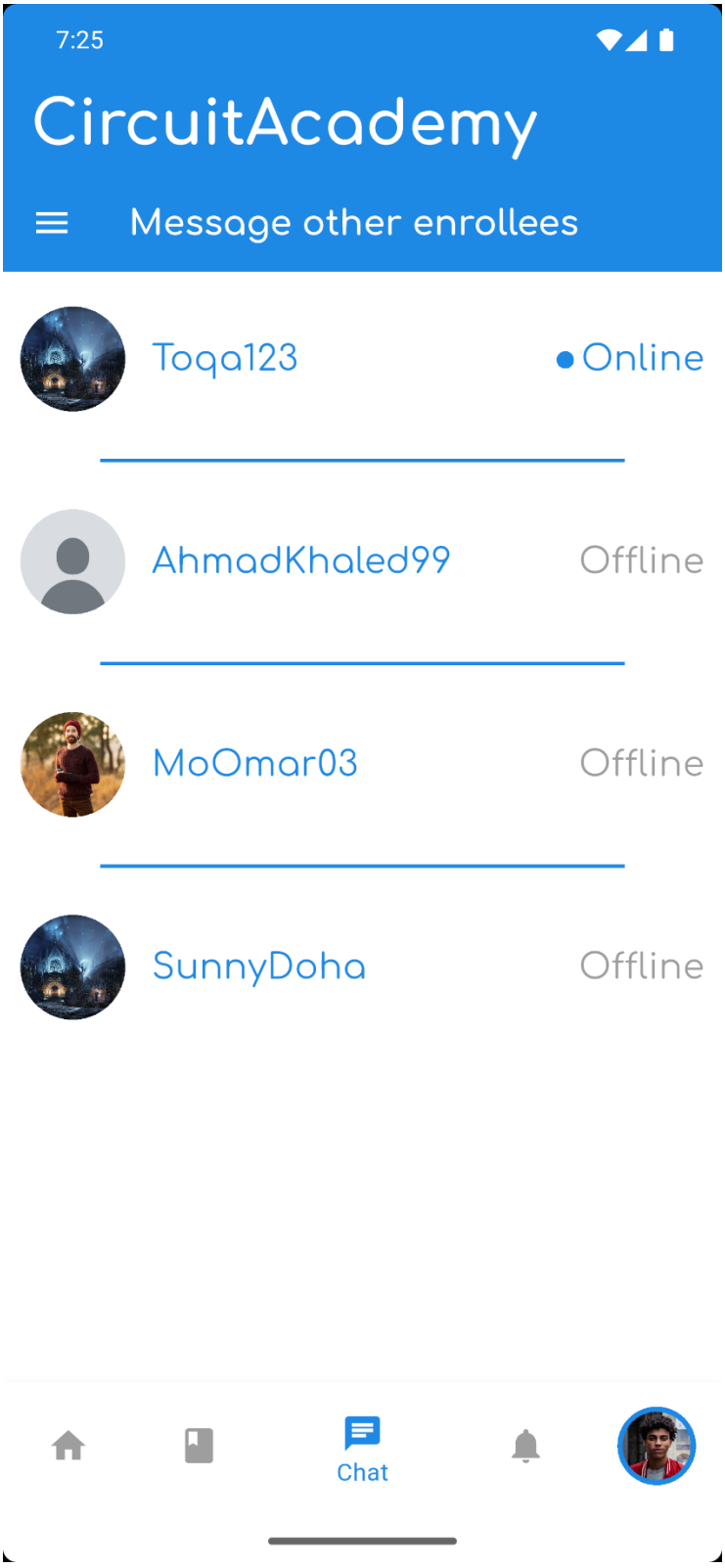


Figure 101: Mobile chat page after course selection

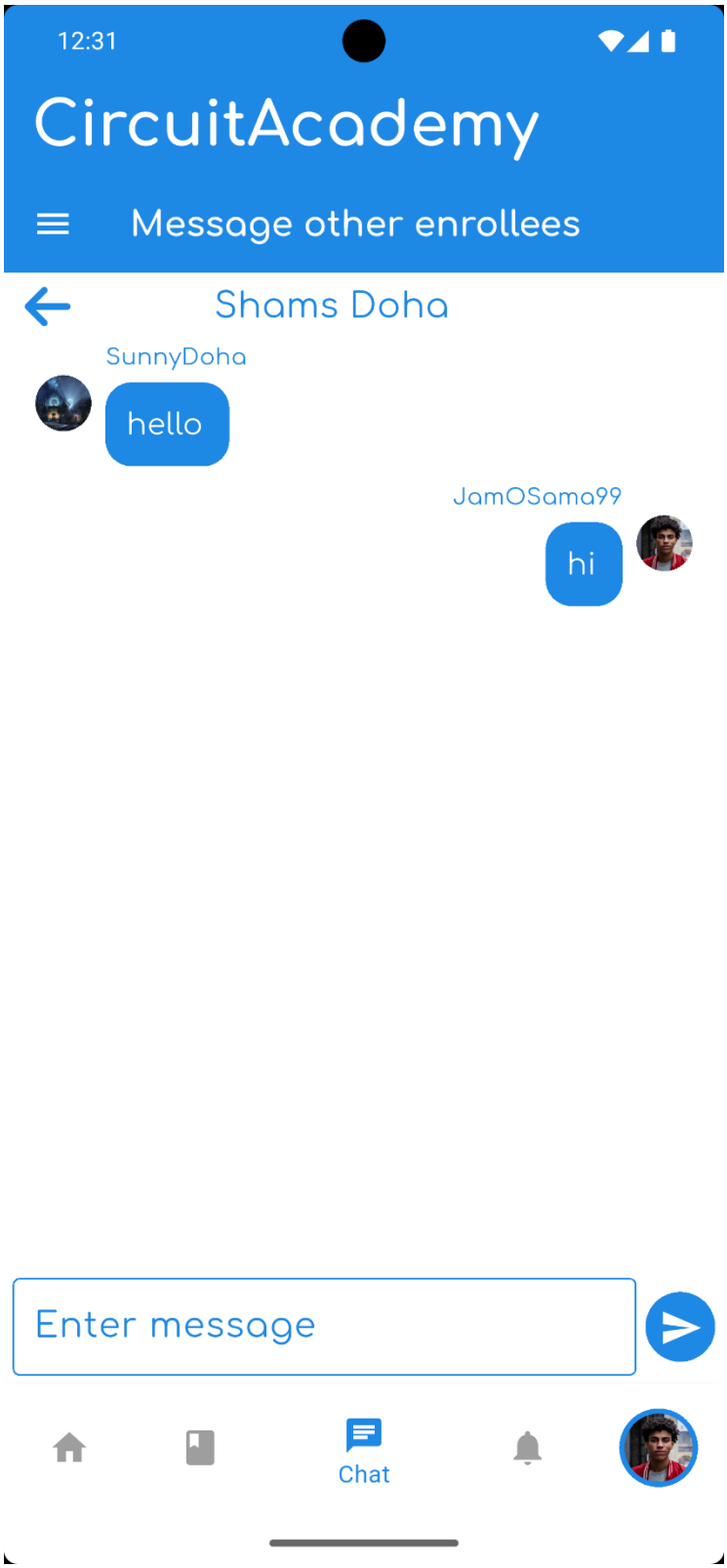


Figure 102: Mobile chat page after user selection

Users can change the selected course at any time like the feed page.

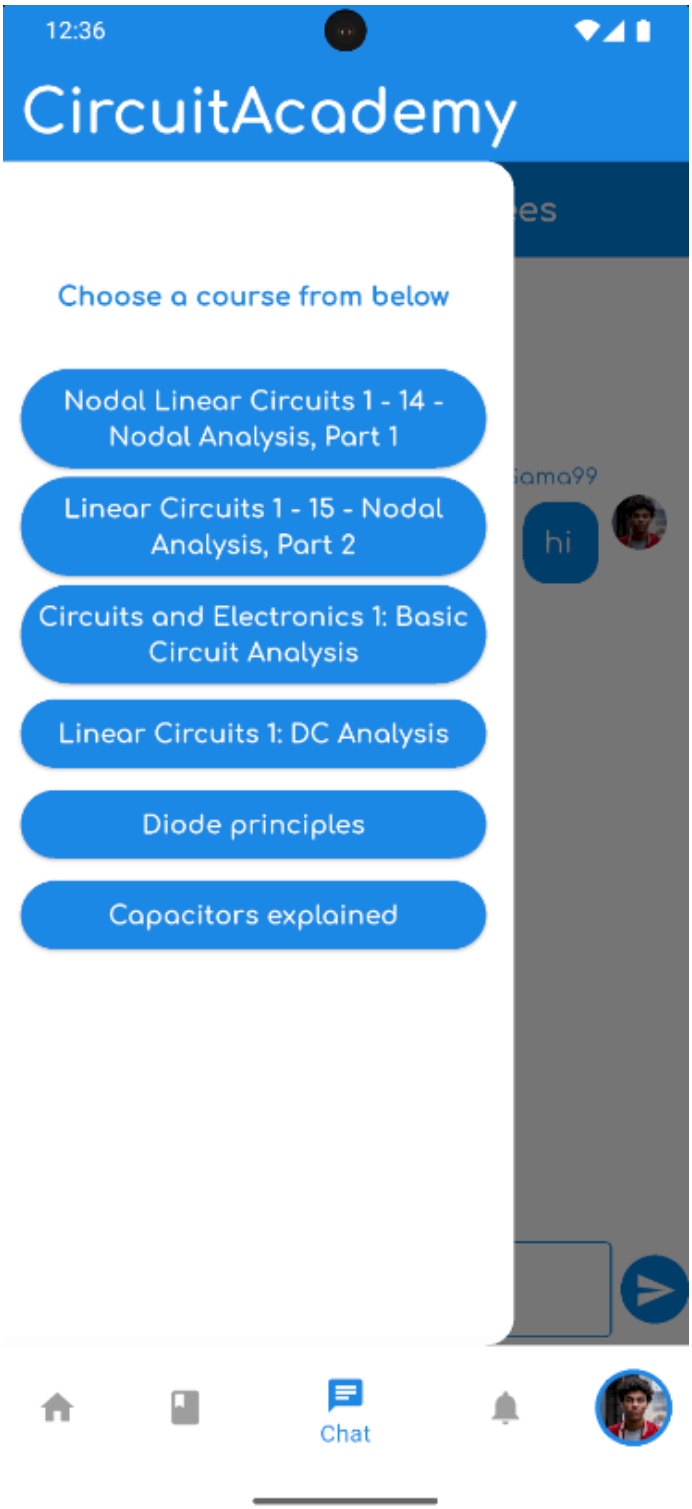


Figure 103: Mobile chat page adjusting course selection

Let’s assume user selects “Linear circuits” course, enrollees list changes accordingly

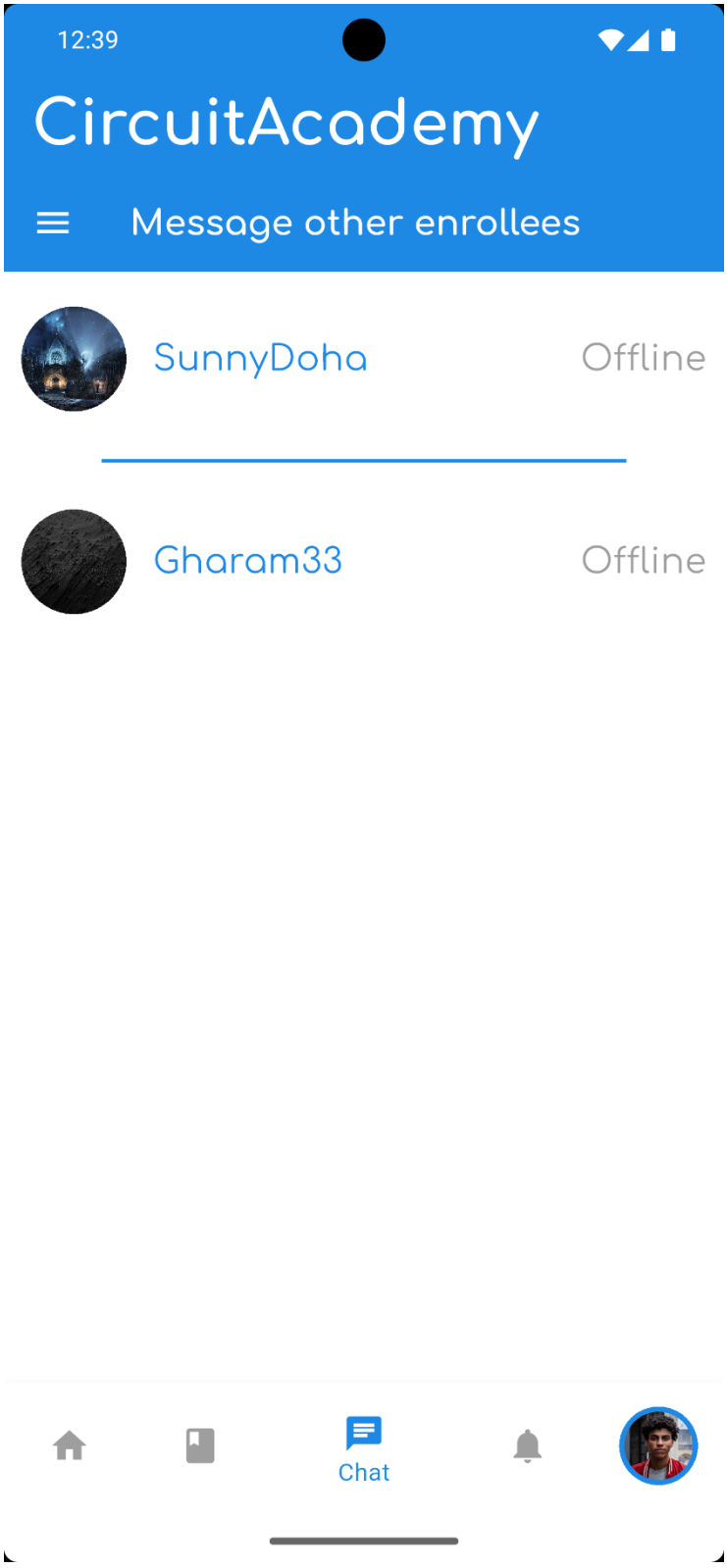


Figure 104: Mobile chat page - last

- **Notifications page:** Chat messages and request status appear on the notifications page, they also appear if the app was not running to ensure good user experience and functionality. They appear from newest to oldest as they should.

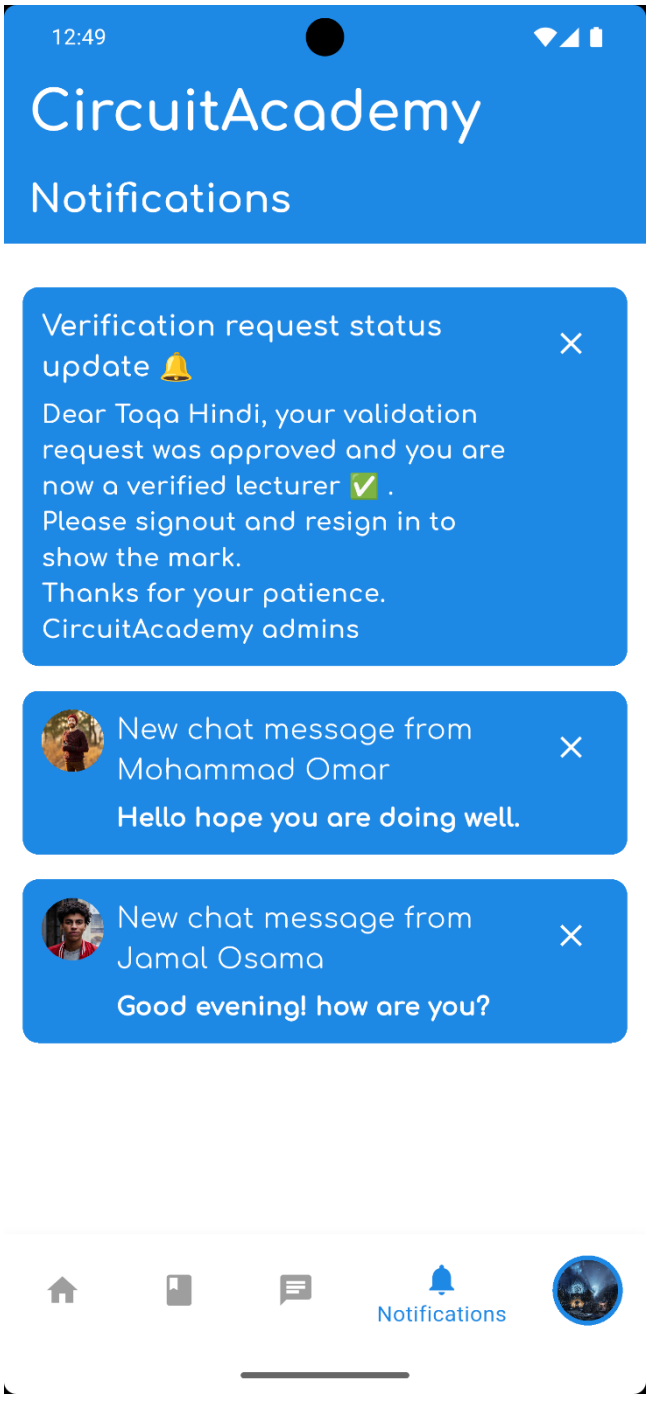


Figure 105: Mobile notifications page

When there are new notifications or unread ones, the UI updates to show the user there are missed notifications

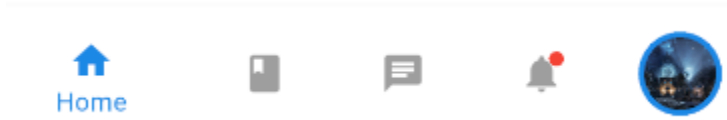


Figure 106: Mobile unread notifications

Also, while the user is using the application or not, a local notification appears that navigates the user to the notifications page when clicked

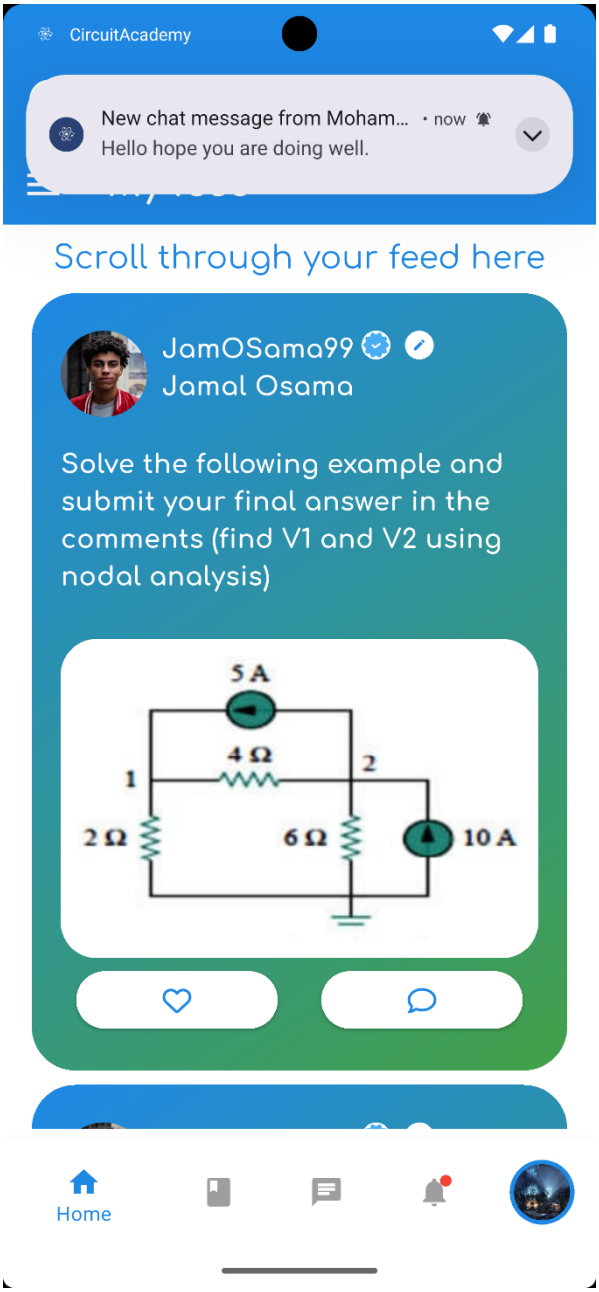


Figure 107: Mobile notification while using app

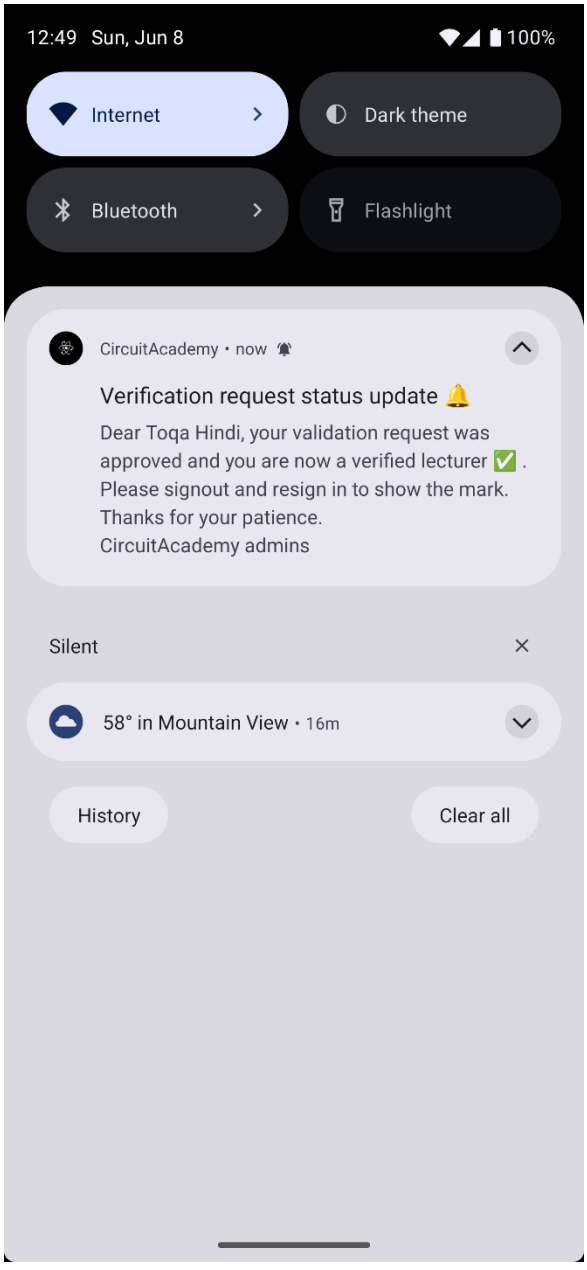


Figure 108: Mobile notification while not using app

- **Profile page:** Shows some information about the user and allows user to edit his / her information, change the application's theme, open the simulator in an external browser, or sign out. It also shows whether the user is verified or not.

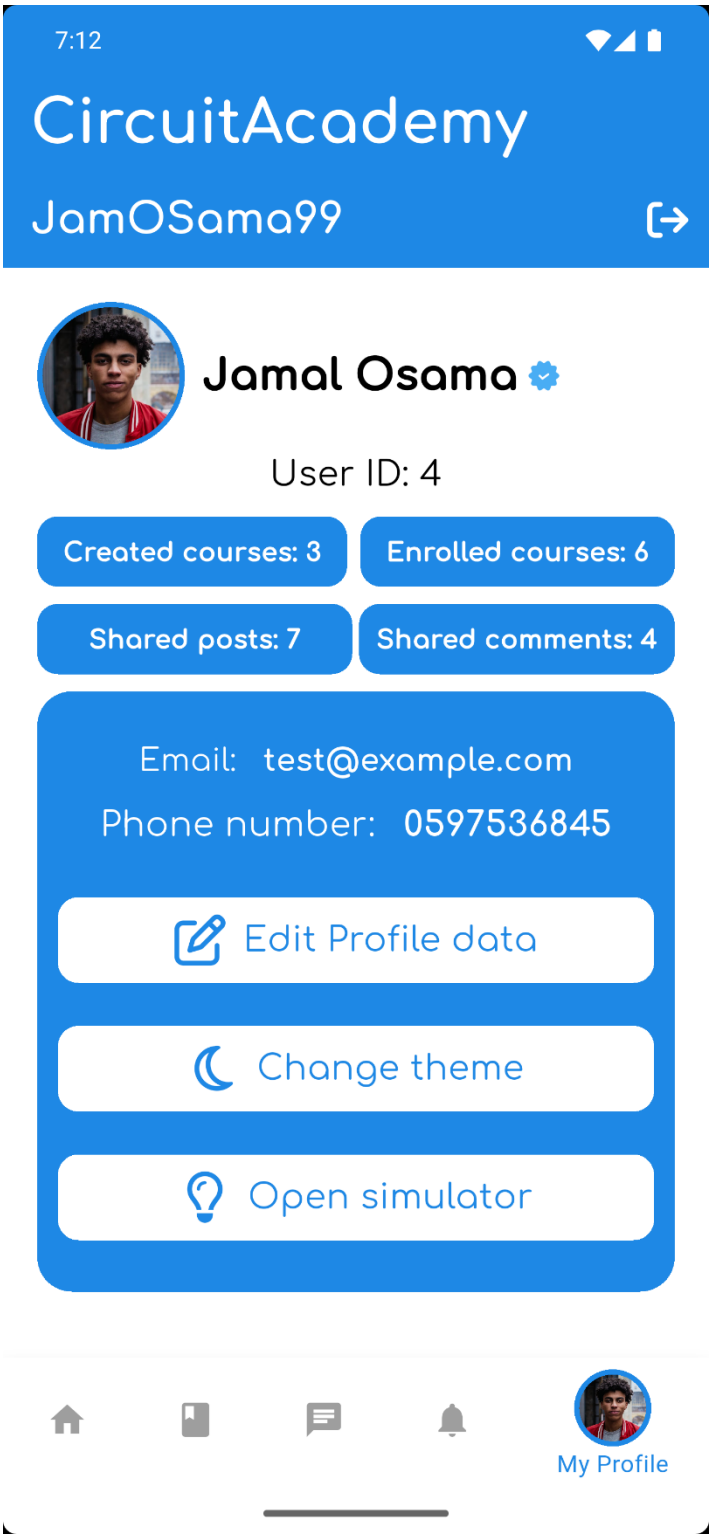


Figure 109: Mobile profile page

- Edit profile page: Allows users to edit their information, change their profile image or upload a certificate and request validation from admins.

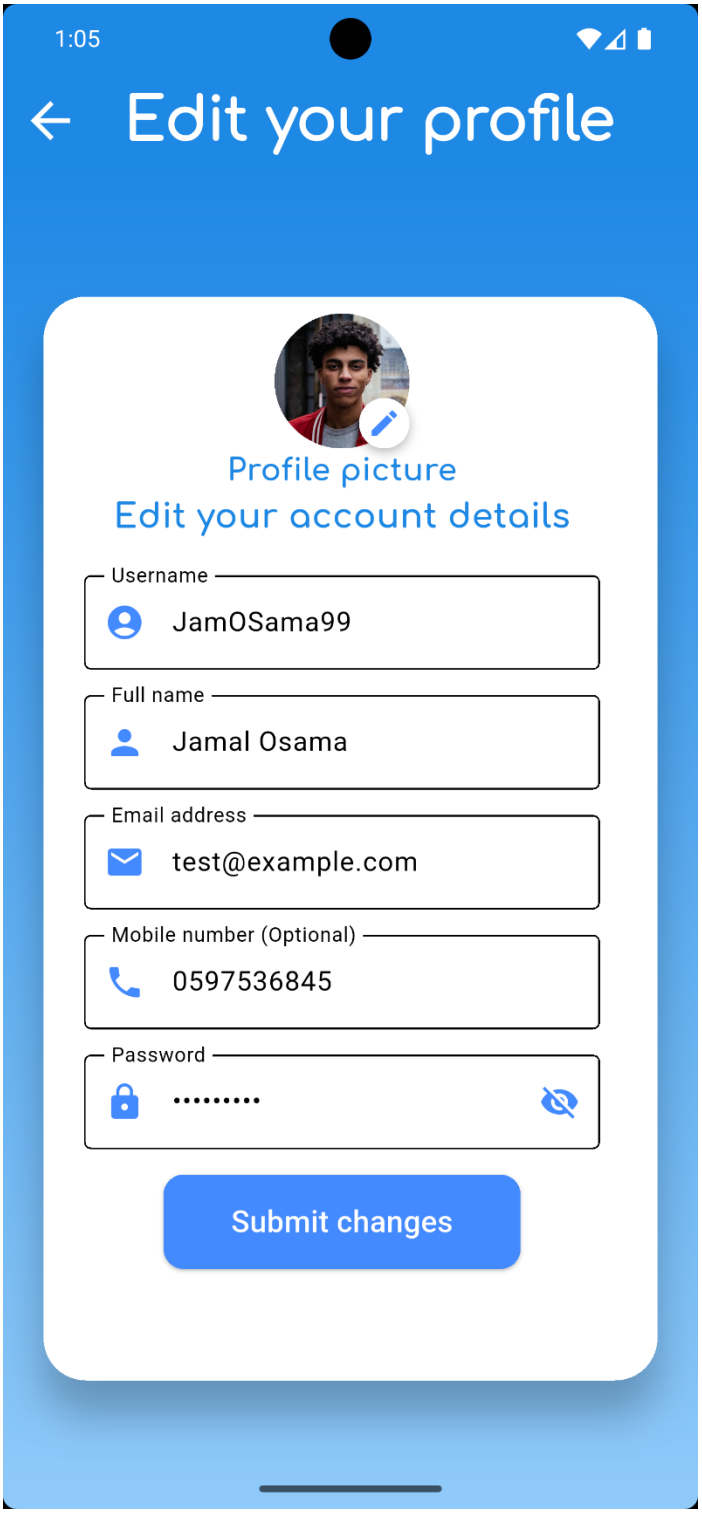


Figure 110: Mobile edit profile page

If the user has not sent a request yet or has not been reviewed by the admins, he can submit a file to be reviewed by them.

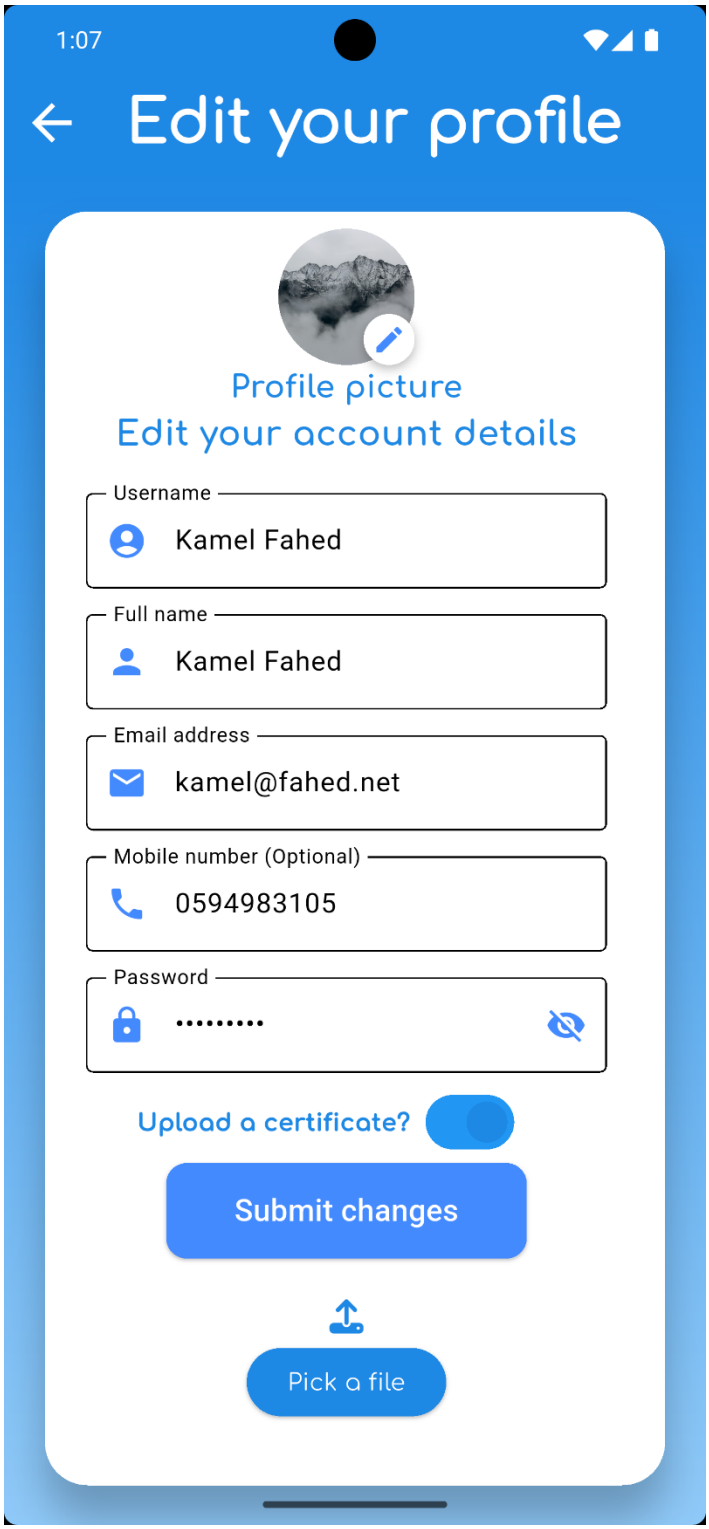


Figure 111: Mobile edit profile - file upload

- **Change theme dialog:** Enables the user to change the theme of the application, it can be set to three values, Light, Dark or Same as system.

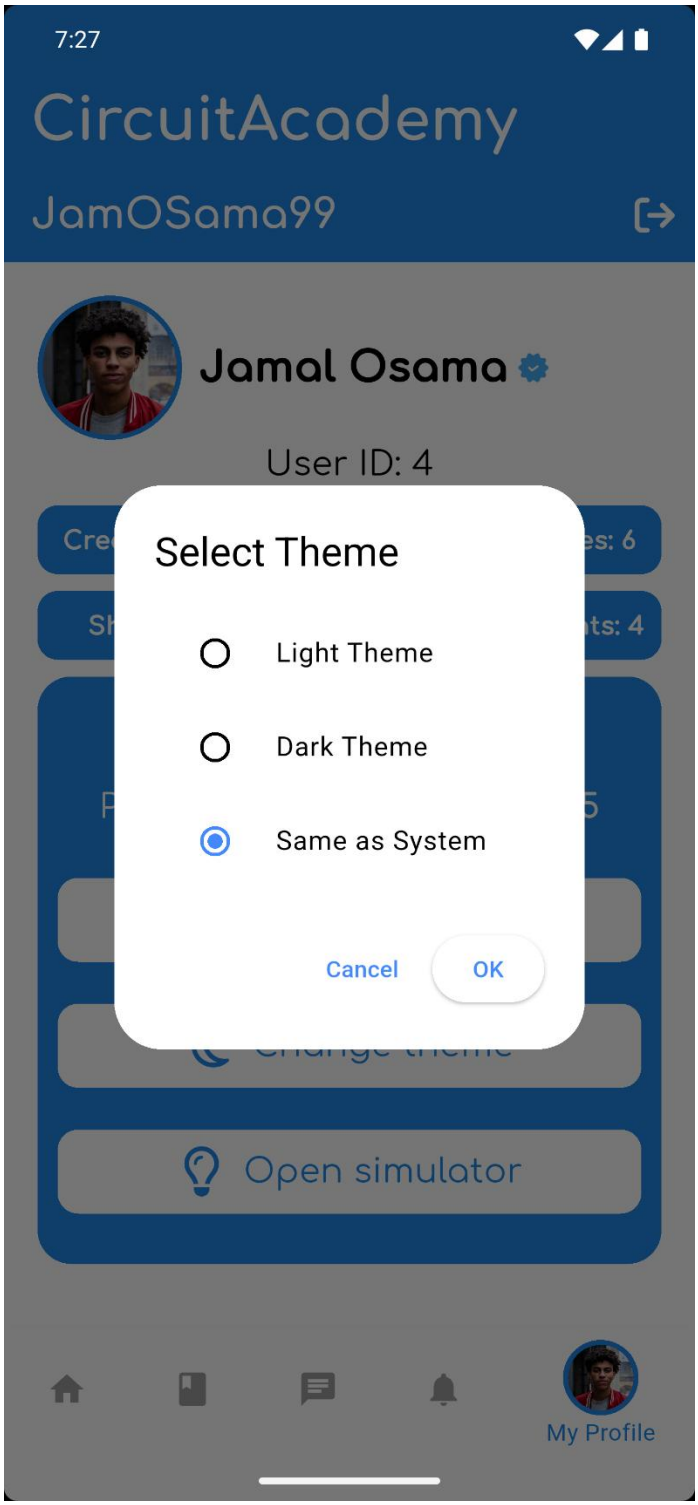


Figure 112: Mobile change theme dialog

The following image shows the feed page as an example of using the dark theme.

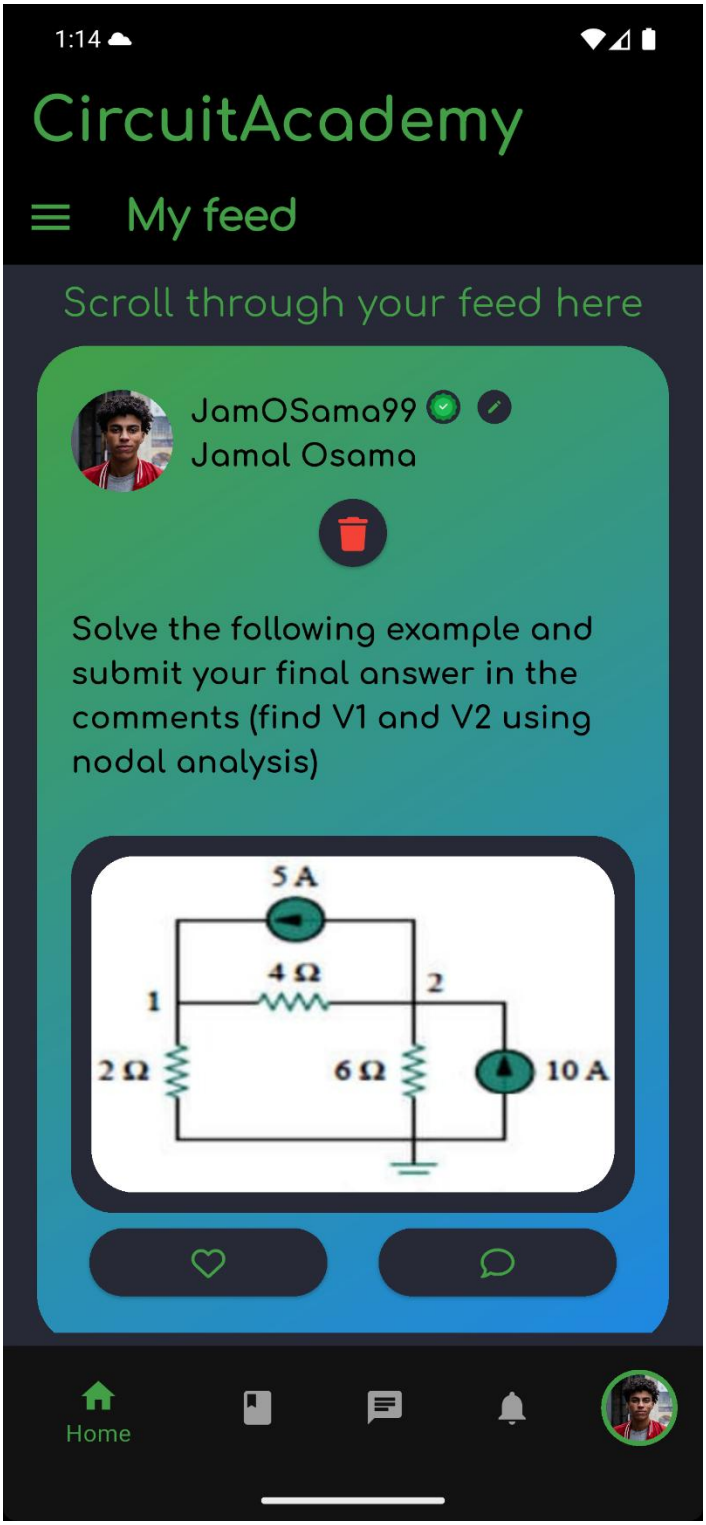


Figure 113: Mobile dark theme

Chapter 4: Results and discussion

CircuitAcademy was developed as a complete educational platform combining circuit simulation, collaborative tools, and course-based learning features. The results demonstrate that the system works effectively across both web and mobile platforms, and fulfills its primary goal of supporting students in learning electronics and circuit analysis in an interactive and accessible way.

The circuit editor allows users to create, modify, and simulate circuits using a simple and intuitive interface. Users can drag and connect components, simulate the circuit in real time using NGSpice, and receive both raw simulation values and symbolic explanations. The explanation system, powered by a Python backend and the SymPy library, provides a detailed breakdown of the solution using Modified Nodal Analysis (MNA), including matrix equations, node voltages, and current formulas.

In AC analysis, Gnuplot is used to render voltage waveforms automatically from the simulation data, enhancing the learning experience. While the explanation system currently supports resistors, capacitors, and inductors, it does not yet support non-linear components like diodes or transistors.

In addition to the simulator, CircuitAcademy includes full support for course creation and enrollment. Users can publish and access electronics-related courses, engage with other learners through community groups, and participate in live educational meetings using integrated video chat features. File sharing, notifications, and real-time messaging are also available.

The platform was tested on both desktop and mobile environments, and all major features were confirmed to function as intended. The user interface remains consistent across devices due to the use of Flutter, and users were able to complete simulations, access content, and communicate without issues.

Overall, the project provides a unified environment for both theoretical learning and hands-on simulation, giving students a more complete and practical understanding of circuit-related topics.

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Chapter 5: Conclusion

5.1 Conclusion

CircuitAcademy successfully delivers a complete and accessible educational platform for learning circuit and electronics concepts. By integrating a real-time circuit simulator with symbolic explanation tools, the platform bridges the gap between theory and practice, helping students understand how circuits work at both a numerical and analytical level.

The use of NGSpice for simulation and SymPy for symbolic analysis ensures accurate results while also providing educational insight into the underlying calculations. Features such as Gnuplot-based waveform visualization, circuit classification, and interactive explanations enhance the tool's educational value.

Beyond simulation, the platform offers a wide range of features, including course publishing, real-time chat, collaborative communities, and live meeting support. These elements make CircuitAcademy more than just a simulator — it is a full learning environment tailored to electronics education.

Cross-platform compatibility was achieved through the use of Flutter, ensuring a consistent experience on both web and mobile. The project demonstrates the value of combining simulation tools with modern educational platforms to provide students with an intuitive and hands-on approach to learning.

In conclusion, CircuitAcademy fulfills its objectives by making electronics education more interactive, collaborative, and accessible, and has the potential to support a wide range of learners in the field of circuits and electronics.

5.2 future work

While CircuitAcademy achieved its main objectives, there are several areas for future development to further enhance its educational value and functionality.

On the simulation side:

- Extend explanation support to circuits containing diodes and transistors, enabling symbolic analysis for non-linear components. This would allow the platform to handle a wider range of practical and real-world circuit designs, which are essential in modern electronics education.
- Introduce support for basic digital components, such as AND, NAND, OR, and NOR gates. This would broaden the scope of the simulator beyond analog circuits, allowing users to design and analyze simple digital logic circuits and laying the groundwork for potential expansion into digital systems and microcontroller education.

Educationally:

- the platform could benefit from quiz modules, instructor-assigned simulations, and step-by-step tutorials linked to specific circuit types. Integrating AI-based hints for common mistakes could also improve user learning outcomes.
- Community features may be expanded to include real-time collaborative circuit editing, commenting on simulations, and progress tracking through achievements or course badges. These tools can help foster peer learning and engagement across users.
- Meeting Screen host controls and media checks which increases satisfaction of users and enhances user experience.
- Finally, general improvements such as offline access, multi-language support, accessibility enhancements, and exporting circuit explanations as PDFs would make the platform more versatile and user-friendly for a broader audience.

5.3 References

[1] J. Á. Ariza. (2023, August). “Bringing active learning, experimentation and student-created videos in engineering: A study about teaching electronics and physical computing integrating online and mobile learning,” Computer Appl. Eng. Educ. 2023 ; 31: 1723 - 1749

[2] K. Ghoulam, B. Bouikhalene, A. Babori, & N. Falih, (2024). “Exploring the impact of mobile devices in electronics e-learning: A case study evaluating the effectiveness of mobile learning applications in the field of electronics and sensors,” Advances in Mobile Learning Educational Research, vol. 4, no. 2, pp. 1058–1072.

[3] T. Trongtirakul, K. Pusorn and U. Peerawanichkul, (2022). "Computer Simulation-Based Learning: Student Self-Efficacy During COVID-19 Outbreak," 2022 7th International STEM Education Conference (iSTEM-Ed), Sukhothai, Thailand, 2022, pp. 1-4, doi: 10.1109/iSTEM-Ed55321.2022.9920763.

[4] P. Moeller, R. S. Piccinin, and T. Oliveira, (2021). “Usability in e-learning platforms: An analysis of design principles,” Int. J. Educ. Technol. High. Educ., vol. 18, no. 1, pp. 1–18.