Design A Website for Learning Internet-Of-Things Programming by Integrating Design Thinking Elements

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ABSTRACT

Industry 4.0 is crucial in the industrial revolution, specifically focusing on interconnectivity, automation, machine learning, and real-time data. In this context, the Internet of Things (IoT) is critical, especially in smart environments, where machines are equipped with sensors and interconnected through web-enabled devices. Hence, individuals in this industry must constantly update their knowledge of IoT programming. Online learning is a flexible approach that allows learners to learn at their own pace and access courses from anywhere. However, existing educational websites for learning IoT programming are hindered by the lack of effective application of instructional design principles. Despite the importance of design thinking, there remains a paucity of evidence that educational websites incorporate critical components of effective learning paradigms. Additionally, these websites do not effectively integrate usability principles to make them easy to use and more pleasant. This study aimed to develop an educational website for learning IoT programming by integrating design thinking principles and the ADDIE model. The study uses a qualitative and quantitative approach in three phases to provide more significant insights. The iterative development process for design principles involves empathise, problem definition, ideating, prototyping, and testing. Meanwhile, the ADDIE model stages include analysis, design, development, implementation, and evaluation. Data were collected from ten learners through a semi-structured interview at the initial stage to identify problems with existing educational websites. Themes and sub-themes were developed from the interview responses using a thematic analysis. The findings were entered into an empathy map, and proposed solutions were used to develop the prototype. In the evaluation/testing stage, the prototype was evaluated by twenty-nine respondents to identify areas of improvement. The study findings were used to make recommendations to improve the prototype to enhance user experience, engagement, and effectiveness in learning IoT programming. The evidence from this study suggests that educational websites should optimize load times, improve mobile accessibility, enhance feedback mechanisms, provide real-time user support, and implement customization features.

ABSTRAK

Industri 4.0 adalah penting dalam revolusi perindustrian, khususnya menumpukan pada kesalinghubungan, automasi, pembelajaran mesin dan data masa nyata. Dalam konteks ini, Internet-of-Things (IoT) adalah kritikal, terutamanya dalam persekitaran pintar, di mana mesin dilengkapi dengan penderia dan saling bersambung melalui peranti yang didayakan web. Oleh itu, individu dalam industri ini mesti sentiasa mengemas kini pengetahuan mereka tentang pengaturcaraan IoT. Pembelajaran dalam talian ialah pendekatan fleksibel yang membolehkan pelajar belajar mengikut kadar mereka sendiri dan mengakses kursus dari mana-mana sahaja. Walau bagaimanapun, laman web pendidikan sedia ada untuk pembelajaran pengaturcaraan IoT terdapat kekurangan dari segi prinsip penggunaan reka bentuk pengajaran yang berkesan. Walaupun pentingnya pemikiran reka bentuk, masih terdapat kekurangan bukti bahawa laman web pendidikan menggabungkan komponen kritikal paradigma pembelajaran yang berkesan. Selain itu, kebanyakan laman web pendidikan tidak menyepadukan prinsip kebolehgunaan dengan berkesan untuk menjadikannya mudah digunakan dan lebih menyenangkan. Kajian ini bertujuan untuk membangunkan laman web pendidikan untuk pembelajaran pengaturcaraan IoT dengan mengintegrasikan prinsip pemikiran reka bentuk dan model ADDIE. Kajian menggunakan pendekatan kualitatif dan kuantitatif dalam tiga fasa untuk memberikan pandangan yang lebih ketara. Proses pembangunan berulang untuk prinsip reka bentuk melibatkan empati, definisi masalah, idea, prototaip, dan ujian. Sementara itu, peringkat model ADDIE merangkumi analisis, reka bentuk,

pembangunan, pelaksanaan dan penilaian. Data dikumpul daripada sepuluh pelajar melalui temu bual separa berstruktur pada peringkat awal untuk mengenal pasti masalah dengan laman web pendidikan sedia ada. Tema dan sub tema dibangunkan daripada maklum balas hasil temu bual menggunakan analisis tematik. Penemuan telah dimasukkan ke dalam peta empati, dan penyelesaian yang dicadangkan digunakan untuk membangunkan prototaip. Dalam peringkat pengujian, prototaip telah dinilai oleh dua puluh sembilan responden untuk penambahbaikan. Dapatan kajian digunakan untuk membuat cadangan untuk menambah baik prototaip untuk meningkatkan pengalaman pengguna, penglibatan dan keberkesanan dalam pembelajaran pengaturcaraan IoT. Rumusan kajian ini menunjukkan bahawa laman web pendidikan harus mengoptimumkan masa muat, meningkatkan kebolehcapaian mudah alih, meningkatkan mekanisme maklum balas, menyediakan sokongan pengguna masa nyata dan melaksanakan ciri penyesuaian.

INTRODUCTION

Background of the Study

Industry 4.0, often referred to as IR 4.0, is a new stage of the Industrial Revolution that places a strong emphasis on automation, real-time data, connectivity, and machine learning (Tsaramirsis et al., 2022). One of the essential elements of smart factories in Industry 4.0 is the Internet of Things (IoT). IoT represents a network of interconnected devices capable of collecting and exchanging data (Zikria et al., 2021). The Internet Protocol (IP) address that sensors on factory floor equipment have enabled them to communicate with other web-enabled devices (Laghari, 2021). Several technologies, such as sensors and actuators, connectivity technologies such as Wi-Fi, cloud computing for storage, and data analytics, come together to make IoT possible (Munir et al., 2017). In the rapidly evolving landscape of the IoT, acquiring programming skills is vital toward unlocking the full potential of interconnected devices. IoT programming is necessary because it allows developers to write the software and algorithms necessary to control and manage connected devices. Hence, the need for diverse programming skills and the constant evolution of technology (Skalka et al., 2021). However, there is a need for effective strategies for learning IoT programming. Such strategies include the use of online educational learning websites. Web-based learning (WBL) involves the use of online course content for education and learning (Ananda et al., 2024; Soussi, 2020). WBL offers effective interaction between the learners and the instructor.

Web-based learning provides learners and educators with access to global resources and databases. It is employed in a variety of educational contexts, including formal education institutions, corporate training, and lifelong learning initiatives (Soussi, 2020). As technology continues to advance, web-based learning platforms evolve to incorporate new features and pedagogical approaches, ensuring a dynamic and practical online learning experience (Kuo et al., 2021). This mode of learning has become increasingly popular due to its flexibility, accessibility, and ability to accommodate diverse learning styles. Instruction design is also a structured arrangement of teaching and learning activities designed to facilitate organised learning experiences (Isman, 2011). Online learning offers learners flexibility and access to educational resources (Berezina et al., 2024). However, online learning may be limited due to a lack of interaction and social engagement, feelings of isolation, and reduced motivation (Berezina et al., 2024).

Design Thinking

Design Thinking (DT) offers a powerful approach to developing effective and engaging educational experiences (Jamal et al., 2021; Razzouk et al., 2012). DT's user-centred approach to problem-solving involves understanding user needs, redefining problems, and creating innovative solutions. (Dam & Siang, 2021). It is a problem-solving approach to improve a product, such as a business or website. The approach helps designers provide innovative solutions through five steps: empathise, define, ideate, prototype, and test (Suratno & Shafira, 2022; Wolniak, 2017). They provide a structured and flexible framework for addressing complex problems with a user-centered approach. It ensures the website is developed based on a deep understanding of user needs and relevant feedback. Because of its broad applicability in a variety of fields, design thinking has emerged as a pedagogical phenomenon in higher education (Tung, 2021; Sandars & Goh, 2020). However, despite the growing educational trend of design thinking in higher education, there remains a significant gap in its application to educational programming, especially in the context of IoT programming

(Avcu & Er, 2000). Hence, employing a user-centred design approach to design the IoT programming course enables a more efficient, enjoyable, and user-friendly learning platform for users.

ADDIE Model

The ADDIE model is highly suitable for developing an online IoT programming website due to its structured and iterative approach that ensures alignment with user needs and educational goals. It involves five stages: analysis, design, development, implementation, and evaluation (Kim & Mun, 2021). This iterative process ensures that the final product addresses learners' needs and adapts to emerging trends and technologies in IoT education, ultimately enhancing the overall learning experience and outcomes. The ADDIE model's emphasis on thorough analysis, meticulous design, iterative development, and user-focused implementation makes it an optimal choice for developing an online IoT programming website that is both effective and engaging.

Problem Statement

Educational websites have been widely used in several fields, such as medical education. These platforms offer significant benefits such as accessibility, flexibility, and the ability to reach a diverse audience. However, not all educational websites are equally effective (Muthuprasad et al., 2019; Cook & Dupras, 2004). For example, while most websites fulfil the criteria for being categorised as general information platforms, a significant number of educational sites fail to incorporate fundamental principles of effective learning. Only 17% of these sites feature the essential elements of the educational paradigm, which include critical thinking, independent learning, evidence-based learning, and feedback (Cook & Dupras, 2004; Dogan & Dikbiyik, 2016; Astuti et al., 2020). Furthermore, fewer than half of the educational websites fail to meet any established criteria due to content that does not engage or motivate learners (Cook & Dupras, 2004; Dogan & Dikbiyik, 2016; Astuti et al., 2020). There are many educational websites in Malaysia to learn IoT programming, such as *https://matgyver.my/*. Nevertheless, the developers do not employ principles of effective learning in their design. For example, developers may not adequately consider the needs, preferences, and skill levels of the target audience. Furthermore, if developers do not employ principles of instructional design, the website may suffer from information overload, making it challenging for learners to follow a structured learning path (Morrison et al., 2019). Hence, when developers neglect to integrate such features, the website may become less engaging, hindering the learning experience. As a result, learners end up abandoning the websites.

Design thinking has transformed into a widespread educational approach across various fields due to its universal applicability (Beligatamulla, 2021). Despite the prominence of DT as an educational method in higher education, there remains a notable deficiency in its application within programming education, particularly in the context of IoT programming (Avcu & Er, 2020). The existing literature shows that DT approach has been applied in online learning (Yesa et al., 2024; Purwanto et al., 2022; Kim, 2020; Kim, 2017). However, only a few studies have investigated its effectiveness in programming websites (Lai et al., 2021; Ferreira Martins et al., 2021; Razzouk & Shute, 2012). Therefore, this study aims to apply design thinking approach integrated with the ADDIE model to develop an online IoT programming website.

Research Questions

I. What are the elements of DT for designing an educational website?

II. How can an IoT programming learning website be designed by integrating DT elements?

III. How to evaluate the proposed design for learning IoT programming that integrates DT elements?

Research Objectives

a) To identify the elements of DT for designing educational websites.

b) To design a website for learning IoT programming by integrating DT elements.

c) To evaluate the proposed design for learning IoT programming by integrating DT elements.

Research Scope

The study focuses on online educational websites, particularly IoT programming websites. The study involves individuals who are currently using online educational websites. The target population is mainly learners in Malaysia. This study does not consider other online websites or courses that do not involve learning programming skills.

Significance of Study

The research contributes from a theoretical and practical perspective.

Theoretical: This study will expand the knowledge regarding designing educational websites by integrating DT elements.

Practical: Findings from this study can guide website developers in designing effective educational websites based on design principles.

Summary of the Chapter

The chapter addresses the evolving landscape of Industry 4.0 and the significance of the Internet of Things (IoT) in this context. The chapter also identifies the need for practical IoT programming skills and emphasizes the importance of instructional design principles in shaping educational websites. The problem background highlights issues in the design of educational websites, particularly in the context of IoT programming, where principles of effective learning are often overlooked. The problem statement highlights the gap in applying design elements to improve the design of educational websites for IoT programming. The research questions focus on identifying design thinking elements, designing an IoT programming learning website with design thinking integration, and proposing designs. The research objectives involve identifying, designing, and evaluating the integration of design thinking elements in IoT programming learning. Finally, the research scope emphasis's IoT programming education, and the significance of the study lies in enhancing the educational experience, preparing learners for the IoT industry, and improving user experience in educational websites.

Project report Outline

The First Chapter summarizes the study background and the motivation for this study. It also explains the research problem and the research questions, goals, and significance of the study.

The Second Chapter details instructional design, including its models. The chapter discusses web-based learning and its advantages. Instructional design for web-based learning and problem-based learning are also presented. This chapter also discusses Internet of Things (IoT) programming, including the application of instructional design for learning programming. Additionally, the sub-sections explore web-based learning for IoT programming design thinking in instructional design. Finally, the gaps in the literature are presented in this chapter.

Chapter Three focuses on the methodology, research approach, and methods used to collect and analyse the data relevant to this study. The chapter discusses the design method approach used for this study.

Chapter Four provides the design thinking stage results. It presents the common issues identified by learners through a human-centred problem-solving process. The chapter presents insights from semi-structured interviews with learners and thematic analysis results. Also, the chapter includes an empathy map, defined issues, proposed solutions, and an affinity diagram.

Finally, Chapter Five discusses the website evaluation findings and implications. It also provides recommendations for enhancing the prototype.

LITERATURE REVIEW

Introduction

This chapter details instructional design, including its models. The chapter discusses web-based learning and its advantages. Instructional design for web-based learning and problem-based learning are also presented. This chapter also discusses Internet of Things (IoT) programming, including the application of instructional design for learning programming. Additionally, the sub-sections explore web-based learning for IoT programming design thinking in instructional design. Finally, the gaps in the literature are presented in this chapter.

Keywords Definition

Instructional Design

Instructional Design can be defined developing instructional materials and activities with the goal of facilitating learning and improving performance (Sweller, 2021). Instruction design is also a structured arrangement of teaching and learning activities designed to facilitate organized learning experiences (Isman, 2011).

IoT Programming

IoT Programming is defined as developing software applications and code that enable devices, sensors, and everyday objects to connect, communicate, and exchange data within the IoT ecosystem (Rahman et al., 2016).

Design Thinking

Design Thinking can be defined as an iterative problem-solving approach that involves understanding users, questioning assumptions, and reframing problems to discover alternative strategies and solutions beyond the scope of initial understanding (Dam & Siang, 2021).

Instructional Design

Instructional design is concerned with improving one aspect of education through optimal means (Xie & Rice, 2021). It is aimed at making learning more effective, effective, and easier. The history of instructional design dates to the early 20th century, with roots in behaviorism and the application of psychology to education. The field has evolved over the years, incorporating technological advancements, cognitive psychology, and learning theories (Sweller et al., 2021). Technology has significantly influenced instructional design, shaping the way educational content is delivered, accessed, and experienced (Gagane et al., 2005). For example, commercialisation of personal computers in the 1980s added technological components to instructional design. Currently, the use of e-leaning platforms, collaborative tools, social media, games, artificial intelligence, data analytics has created effective learning experiences for learners (Xie & Rice, 2021; Sweller et al., 2021). Thus, integrating technology into instructional design can enhance engagement, accessibility, and the overall effectiveness of educational programs.

Instructional Design Models

Instructional design models provide systematic frameworks that guide the creation of effective learning experiences. These models help instructional designers plan, develop, and implement instruction in a structured and organized manner. Some of the most used instructional design models include ADDIE Model, Gagne's Nine Events of Instruction, Kemp Design Model, Merrill's Principles of Instruction (MPI), Rapid Prototyping Model, and Successive Approximation Model (SAM).

(a) Analysis, Design, Development, Implementation, Evaluation (ADDIE) is one of the most widely used and traditional instructional design models. It involves five iterative stages, starting with the analysis of

learning needs and ending with the evaluation of the instruction's effectiveness. Designers can revisit and revise each stage based on feedback and evaluation results.

(b) Gagne's Nine Events of Instruction identifies nine events that should occur during instruction to optimize learning. The events include gaining attention, informing learners of the objective, stimulating recall of prior learning, presenting the stimulus, providing guidance, eliciting performance, providing feedback, assessing performance, and enhancing retention and transfer.

(c) Kemp Model includes eight components: identify instructional problems, analyse learner characteristics, define objectives, sequence content, design instructional strategies, plan instructional message and media, develop materials, and evaluate.

(d) Merrill's Principles of Instruction characterises five principles of instruction: task-centered, activation, demonstration, application, and integration. It emphasises the importance of real-world problem-solving and active learning.

(e) Rapid Prototyping Model involves quickly creating prototypes of instructional materials to gather feedback and make improvements. It's an iterative process that supports testing of ideas and concepts early in the design process.

(f) Successive Approximation Model (SAM): SAM is an agile and iterative instructional design model consisting of three phases namely, preparation, iteration, and evaluation. It promotes collaboration and flexibility, allowing for continuous improvement and adjustments based on feedback.

Web based Learning

Web based learning (WBL) involves the use of online course content for education and learning (Soussi, 2020). WBL offers effective interaction between the learners and instructor. It is also flexible, expensive to deliver, affordable and timesaving. In addition, WBL provides learners and educators with access to global resources and databases. Web-based learning is employed in a variety of educational contexts, including formal education institutions, corporate training, and lifelong learning initiatives (Soussi, 2020). As technology continues to advance, web-based learning platforms evolve to incorporate new features and pedagogical approaches, ensuring a dynamic and effective online learning experience (Kuo et al., 2021).

Types of Web-based Learning

Some common web-based learning offer unique features and benefits to support diverse learning needs (Kuo et al., 2021; Sharifov & Mustafa, 2020; Proskura & Lytvynova, 2020).

a. **Asynchronous Learning:** Involves learners to access course materials and participate in activities at their own pace and convenience. Instructors and learners interact through discussion forums, email, or messaging platforms.

b. **Synchronous Learning:** Involves real-time interaction between instructors and learners, usually through video conferencing, live chat sessions, or webinars. This approach involves participants interacting with each other and the instructor in real time and simultaneously.

c. **Blended Learning:** This method combines traditional face-to-face instruction with online learning components. It allows for flexibility in learning.

d. **Massive Open Online Courses (MOOCs)** are large-scale online courses open to anyone. They are usually run by universities or online learning platforms using video lectures, interactive assignments, and discussion forums.

e. **Virtual Classrooms** simulate a traditional classroom environment in an online setting. This approach allows real-time interaction, discussions, and collaborations between instructors and learners via a virtual learning platform.

f. **Gamified Learning** incorporates game elements and mechanics into the learning process to engage and motivate learners. To promote active participation among learners, they earn points, badges, or rewards based on their progression throughout the course.

Advantages and Disadvantages of Web-based Learning

Web-based learning offers several advantages that contribute to its popularity and effectiveness in various educational and training contexts (Astuti et al., 2020; McKimm et al., 2003). Some key advantages of web-based learning:

a. It is a tool for creating the process of learning alive, concrete, and interesting.

b. It can be accessed anytime and anywhere from any device using any operating system like android, windows, and others.

c. It provides access to educational resources and courses from anywhere with an internet connection.

d. Learners can progress through the content at their own pace (self-paced)

e. Online courses can accommodate many participants simultaneously.

f. Learners can access resources and update their skills continuously, allowing for lifelong learning and staying current in rapidly evolving fields.

g. Web-based learning facilitates collaboration and networking among learners.

There are also some disadvantages of web-based learning:

a. Online learning does not have the face-to-face interaction as in traditional classrooms, which can limit real-time discussion, collaboration, and immediate feedback.

b. Technical issues like internet connectivity problems, software compatibility issues, and platform malfunctions can disrupt the learning experience.

c. Web-based learning requires learners to have strong self-discipline and time management skills.

d. Unreliable online content can affect the accuracy and validity of information and instruction.

e. Students from disadvantaged backgrounds may face barriers to participating fully in web-based learning due to limited access to necessary resources or digital divide.

f. In some countries, compatibility and restrictions are obstacles to the adoption and effective utilisation of web-based learning systems.

Instructional Design for Web-based Learning

Instructional design for web-based learning involves a systematic and learner-centered approach to creating effective online educational experiences (Sancar-Tokmak & Dogusoy, 2023). Creating compelling and interactive online learning experiences requires blending educational principles with technology (Berge, 1998). This iterative process involves continuous assessment and improvement to address learners' needs and accomplish specific learning goals.

Problem Based Design

Problem-based design refers to an approach in the design process where the design solutions are developed in response to identified problems or challenges (Hung, 2019). This methodology is particularly prevalent in fields such as engineering, product design, and problem-solving disciplines. Instead of starting with predefined specifications or requirements, problem-based design begins with a thorough understanding and analysis of the issues or challenges that need to be addressed (Genareo & Lyons, 2015). This approach aligns with the broader concept of human-centered design, where the emphasis is on understanding and addressing the needs of the end-users in a helpful and effective manner.

IoT Programming

Internet of Things (IoT) programming refers to the development of software applications that enable devices to communicate and exchange data within the IoT ecosystem (King, 2021). IoT programming is applied to various contexts including device communication, data processing, security implementation, cloud computing, device management, Machine Learning and Artificial Intelligence (AI) Integration (King, 2021). IoT programming requires a multidisciplinary approach, combining software development skills with an understanding of hardware, networking, and data analytics. Designing instructional materials for learning programming involves a thoughtful and structured approach to help learners acquire coding skills effectively.

Instructional Design for Learning Programming

Some important steps in instructional design for learning programming include:

a. Understand the learners' existing knowledge of programming and their learning styles.

b. Define learning goals with clear objectives.

c. Adopt a structured curriculum for better comprehension and retention.

d. Implement hand-on practice involving coding exercise, case studies, and real-world projects to reinforce theoretical concept.

e. Use interactive learning to engage learners.

f. Implement virtualization and simulations to help understand complex concepts.

g. Incorporate feedback and assessments to reinforce learning.

h. Implement iterative design and continuous improvement.

Combining these principles in instructional design, educators can create engaging, effective, and inclusive learning experiences for individuals seeking to learn programming skills (Guney, 2019; Duran, 2018; Caspersen & Bennedsen, 2007).

Design Thinking

Design Thinking (DT) is a human-centered problem-solving approach that emphasises empathy and iteration to develop innovative solutions (Dam & Siang, 2021). It is a problem-solving approach to improve a product such as a business or website. Dt has been a topic of instruction, exploration, and practical use across various fields of education, research, and industry for many years (Pande & Bharathi, 2020). It has found extensive application in education, spanning a range of fields and educational levels, including middle schools, post-graduate studies, and in disciplines such as Engineering, Management Studies, and Entrepreneurship.

Phases of Design Thinking

The design thinking process involves several interconnected phases ranging from three to seven. However, they are based on the same principles. This study focuses on the most popular five-phase model proposed by Hasso-Plattner Institute of Design at Stanford (Dam & Siang, 2021). The five phases of design thinking is empathise, define, ideate, prototype and test as presented in Table 2.1.

Table 2.1 Stages of Design Thinking

Stage	Definition	Source
Empathize	Understand the needs, thoughts, and feelings of the end-users.	Suratno and Shafira (2022)
Define	Clearly articulate the problem based on insights gained during the empathise phase.	Carlgren et al. (2016)
Ideate	Generate a wide range of creative solutions to the defined problem.	Corrales-Estrada (2020)
Prototype	Build representations of selected ideas to test and communicate concepts.	Carlgren et al. (2016)
Test	Evaluate prototypes with end-users to gather feedback and refine solutions.	Carlgren et al. (2016)

The model Figure 2.1 aims to foster continuous learning, collaboration, and user-centric problem-solving throughout the entire process. Additionally, each phase involves collaboration with interdisciplinary teams and stakeholders, emphasizing the importance of diverse perspectives in the design process. Integrating design thinking elements into learning IoT programming can enhance the educational experience by fostering creativity, problem-solving, and a user-centered approach.

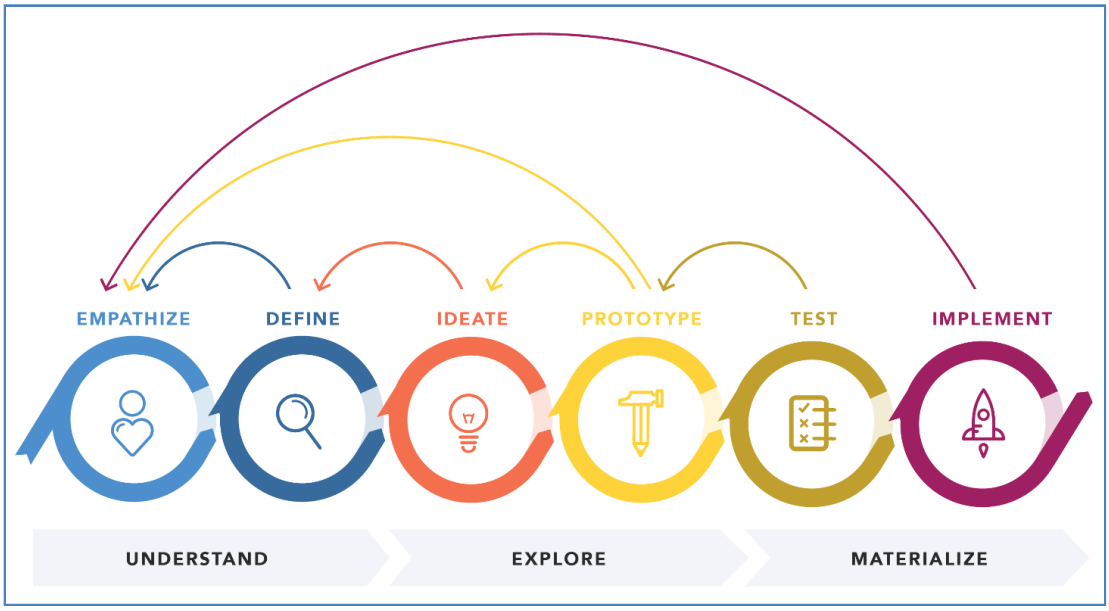

Figure 2.1 Design Thinking Process

Web based Learning for IoT Programming

Web-based learning for IoT programming refers to educational programs and courses delivered through online platforms that focus on teaching and acquiring skills related to IoT programming (Akbar et al., 2018). In this context, individuals can access learning materials, lectures, and interactive content over the internet to gain

expertise in programming for IoT applications. Web-based learning for IoT programming may include various elements such as online courses, interactive simulations, discussion forums, collaborative projects, and video lectures (Kumar et al., 2021; Farhan et al., 2018). Several websites provide valuable resources and tutorials on IoT programming, an example is the coded project website in Figure 2.2 which uses the Raspberry PI module.

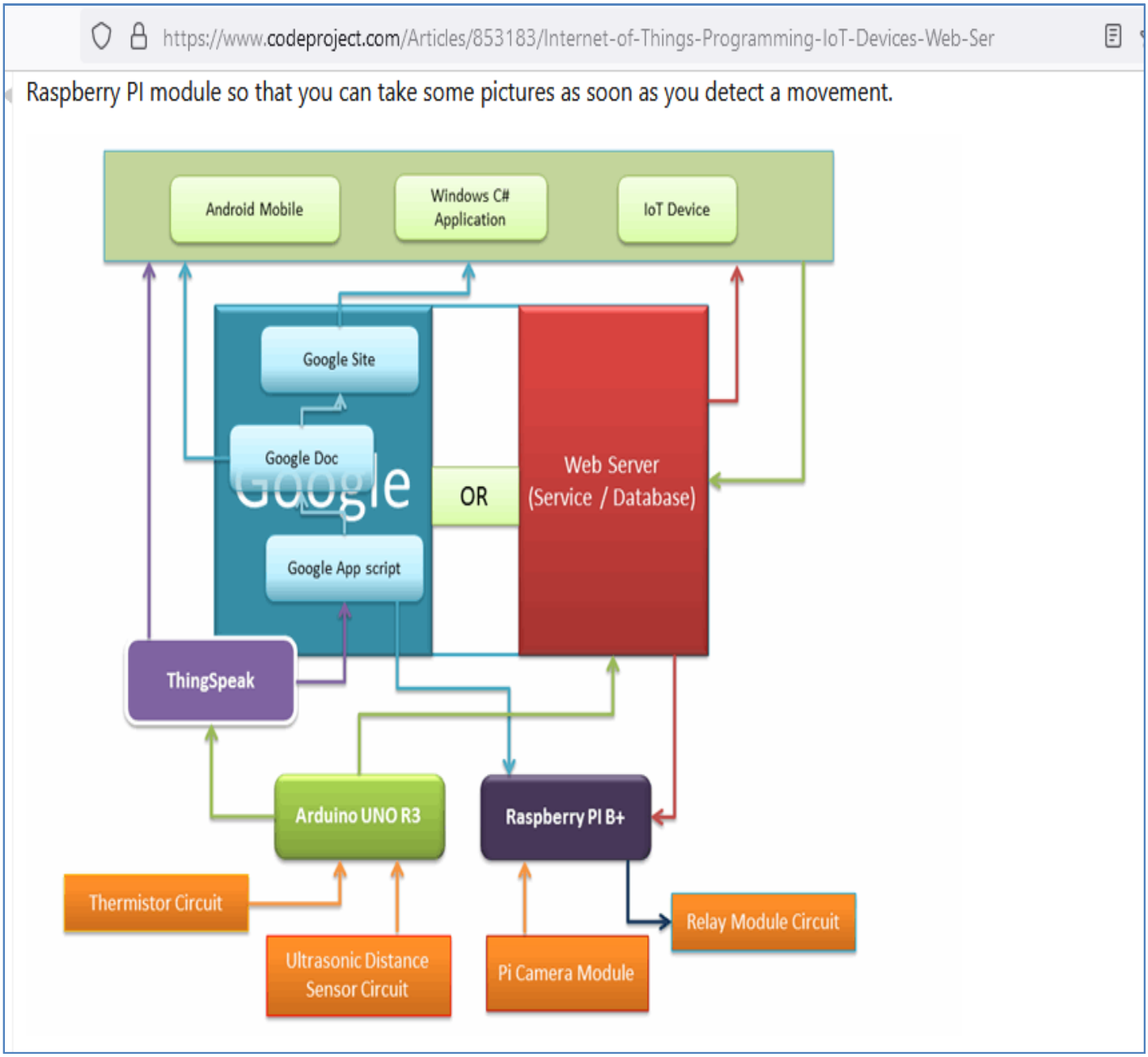

Figure 1.2 Website on IoT Programming

Design Thinking Process in Instructional Design

Design thinking in instructional design involves applying a human-centered and iterative problem-solving approach to the development of educational materials and learning experiences. DT is increasingly being recognized and utilized as a valuable process in instructional design to create innovative and effective learning experiences (Razali et al., 2022; Razzouk & Shute, 2012). The application of design thinking in instructional design can create more effective learning experiences for learners (She et al., 2022). The design focus has evolved from content creation to learning experience. Design thinking has several principles that guide its application (Poleac et al., 2022; Rauth et al., 2010). Some principles of design thinking are illustrated in Figure 2.3. Hence, applying these principles helps create a dynamic and user-centered problem-solving approach that is particularly effective in instructional design.

Human-centered	Design thinking is a human-centered process. The focus is on making people the source of inspiration and direction for solving design challenges.
Mindful of Process	A critical mindset in design thinking is being "mindful of process" or having metacognitive awareness.
Empathy	Empathy is the intellectual identification with or vicarious experiencing of the feelings, thoughts or attitudes of others. Empathy develops through a process 'need finding' in which one focuses on discovering peoples' explicit and implicit needs.
Culture of Prototyping	The mindset of creating and maintaining a "culture of prototyping" focuses on being highly experimental, building to think, and engaging people with artifacts.
Show Don't Tell	As a mindset, "show don't tell" takes traditional visualization one step further, as it includes sketching and traditional prototyping, digital communication and storytelling.
Bias Toward Action	Bias Toward Action is a focus on action-oriented behavior rather than discussion-based work. A "bias toward action" mindset utilizes all modalities of learning.
Radical Collaboration	This mindset is built upon the idea that radically diverse multidisciplinary teams will lead to greater innovations than teams that come from the same discipline. Examining and confronting team dynamics is an essential component.

Figure 2.3 Design Thinking Principles

An example of design thinking is blogging which enables students to reflect on their knowledge, experiences, and ideas while offering suggestions and available resources. In a recent study, design thinking enables students to solve problems rather than complain about them (Novak & Mulvey, 2021). Hence, students were able to change their perspectives. In addition, they were able to gain better insights into the importance of design thinking as reflected in Figure 2.4.

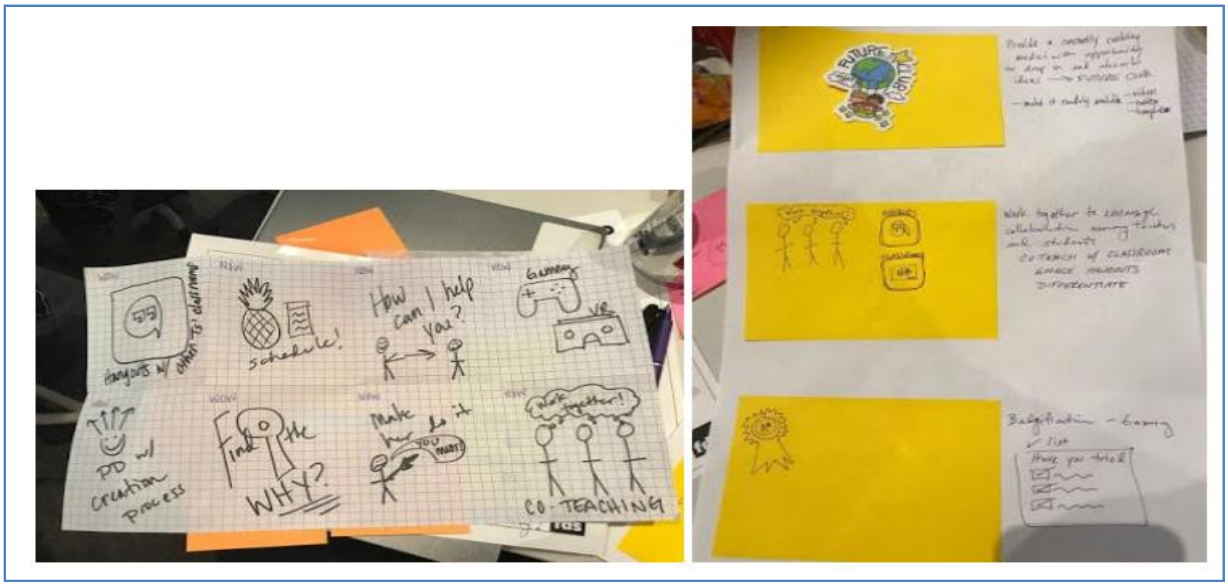

Figure 2.4 Example Design Thinking in Education

Gaps in Literature

a. Research on design thinking education that facilitates the acquisition of knowledge related to design processes and practices is limited (Lawal & Rafsanjani, 2022; Rafiq et al., 2020; Corno et al., 2019). Much of the existing research on design thinking in education focuses on its application and outcomes rather than the process of acquiring knowledge about design thinking itself. While there is a wealth of literature on how design thinking can be applied in various educational contexts, there needs to be more emphasis on how learners understand design processes and practices.

b. Compared to traditional educational subjects with well-established curricula and frameworks, design thinking education often needs more standardized approaches and assessment methods (Guaman-Quintanilla et al., 2023; Koh et al., 2015). Hence, it becomes difficult for researchers to compare and generalize findings across different studies, leading to fragmented knowledge and a limited understanding of how design thinking knowledge is acquired. Understanding and teaching design thinking requires addressing various dimensions, including creativity, problem-solving, empathy, collaboration, and iteration.

c. Several studies reported that developers do not employ effective learning principles in designing web based IoT programming courses (Cook & Dupras, 2004; Dogan & Dikbiyik, 2016; Astuti, Wihardi & Rochintaniawati, 2020). Developers creating web-based courses on IoT programming may primarily possess technical expertise in programming languages and software development (Morrison et al., 2019). However, they may need a background in pedagogy or instructional design. Consequently, they may prioritize technical content over principles of effective learning, leading to challenging courses for learners to engage with and comprehend. This emphasis on technical content may result in courses that are dense with information but require more effective instructional strategies to scaffold learning and promote comprehension. Thus, developers may not fully understand their target audience's needs, preferences, and prior knowledge when designing IoT programming courses.

Chapter Summary

This chapter explores the concept of instructional design and its role in enhancing education by employing optimal methods to make learning more effective, efficient, and accessible. Several instructional design models are included, such as ADDIE, Gagne's nine events of instruction, KEMP model, Merrill's principles of instruction, rapid prototyping model, and successive approximation model. This chapter also discusses web-based learning (WBL) and highlights instructional design for web-based learning. The chapter introduces problem-based design, an approach responding to identified challenges that aligns with human-centered design principles. Furthermore, the chapter presents a general overview of IoT programming, instructional design for learning programming, design thinking, and its phases. The chapter concludes by highlighting gaps in literature, emphasizing limited research on design thinking education and the underutilization of effective learning.

METHODOLOGY

Introduction

This section focuses on the methodology, research approach, and methods used to collect and analyse the data relevant to this study. Research epistemologies, approaches, data collection methods, and study sampling are presented. The chapter describes the research process and data analysis. The basis for selecting the constructivist paradigm, qualitative research approach, and semi-interview is highlighted. Also, the study utilises an online-based survey to assess the prototype website. Finally, the chapter discusses the design method approach used for this study.

Research Paradigm

The research paradigm guides all areas of a research plan, including the aim of the study, research question, instruments, and analysis methods (Brown & Duenas, 2020). This included positivism, interpretivism, and constructivism epistemologies (Ballantyne, 2019; Couper, 2020). Positivism is a research paradigm that emphasizes using scientific methods to study observable reality and generate objective knowledge (Couper, 2020). It is rooted in the belief that the world operates according to fixed laws and principles that can be discovered through empirical observation and logical analysis (Ryan, 2018). Interpretivism is a research paradigm that emphasizes understanding the subjective meaning of human experiences and social phenomena (Alharahsheh & Pius, 2020). It is based on the belief that reality is socially constructed and can only be understood through the perspective of the individuals involved (Ryan, 2018). Constructivism is a philosophical paradigm that asserts that knowledge is constructed through human experiences and interactions (Park, 2023). It emphasises the subjective interpretation of reality and the importance of context in understanding phenomena (Park, 2023). Research paradigms and research approaches are closely interconnected. A research paradigm provides a study's philosophical and theoretical foundation, influencing the choice of research approaches and methods.

Research Design

Research design is a framework or blueprint for conducting a research study. It outlines the methods and procedures for collecting, analysing, and interpreting data (Siedlecki, 2020). It outlines the methods and procedures for collecting, analysing, and interpreting data. Research design approaches include qualitative, quantitative, and mixed methods (Siedlecki, 2020).

Qualitative research is primarily exploratory and is used to understand underlying reasons, opinions, and motivations (Saunders et al., 2019). It provides insights into a problem for developing ideas or hypotheses. Quantitative research is used to quantify a problem by generating numerical data that can be transformed into meaningful statistics (Creswell & Creswell, 2018). This method is used to quantify attitudes, opinions, behaviours, and other variables to generalise results from a larger population (Creswell & Creswell, 2018). Mixed methods research combines qualitative and quantitative approaches to understand the research problem comprehensively (Saunders et al., 2019). Hence, it is crucial to understand the different research design approaches to select the most suitable methodology for a study.

Research paradigms significantly influence the choice of research approaches. Positivism aligns with quantitative research, focusing on objectivity, measurement, and statistical analysis to uncover generalizable truths (Saunders et al., 2019). Interpretivism and constructivism align with qualitative research, emphasizing the understanding of subjective experiences, meanings, and context (Creswell & Creswell, 2018). The chosen paradigm shapes how researchers design their studies, collect and analyse data, and interpret their findings (Saunders et al., 2019). Thus, it guarantees the research approach is coherent with their philosophical beliefs about reality and knowledge.

Designing a user interface prototype that provides enhanced user experience requires structured steps to ensure a practical design. This study employs design thinking, which is a constructivist approach (Tsai, 2023; Pande & Bharathi, 2020). Design thinking (DT) is a human-centered problem-solving approach emphasizing empathy and iteration to develop innovative solutions (Corrales-Estrada, 2020). It is a problem-solving approach to improve a product, such as a business or website. The approach helps designers provide innovative solutions through several steps (Suratno & Shafira, 2022). Design thinking assumes that knowledge acquisition requires the learner to actively engage in meaning-making activities in the brain. The five stages of design thinking include empathise, define the problem, ideate, prototype, and test (Wolniak, 2017; Plattner, 2010). They provide a structured and flexible framework for addressing complex problems with a user-centered approach. It ensures the website is developed based on a deep understanding of user needs and relevant feedback. The research aims to create innovative and impactful solutions that address the identified challenges effectively by following this process. The design thinking approach stages are illustrated in Figure 3.1.

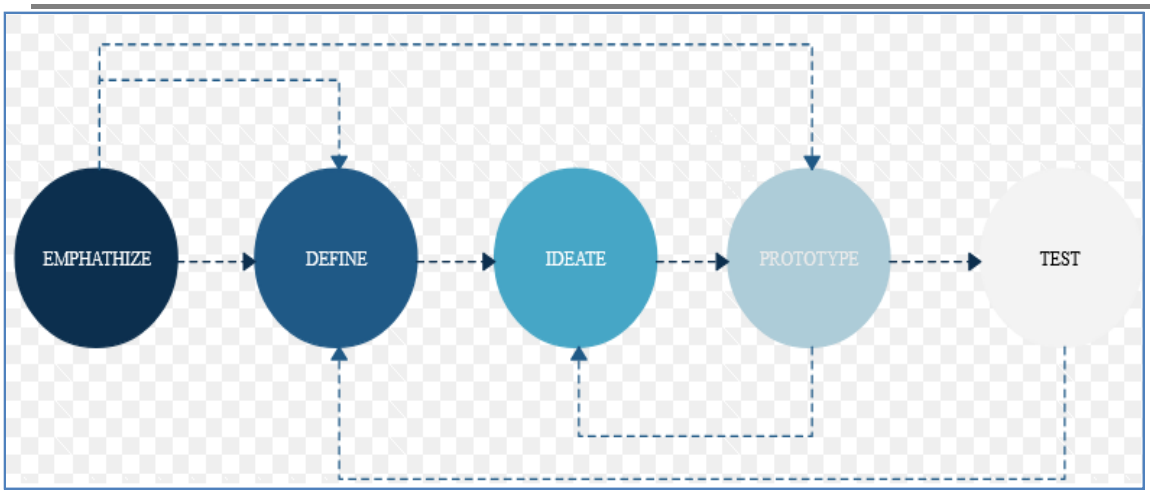

Figure 3.1 Five Stages of the Design Thinking Approach

Stage 1: Empathise

The empathize stage focuses on understanding the users' experiences (Corrales-Estrada, 2020). This involves gathering insights through qualitative methods such as interviews, observations, and surveys (Suratno & Shafira, 2022). It aims to gain a more profound, empathetic understanding of the users' needs, challenges, and perspectives. The semi-structured interview with diverse users aims to capture their experiences and requirements. Users can also be observed to identify how they interact with an existing system or process. Their behavioural patterns when using the system are also observed. Furthermore, online-based surveys are valuable in gathering quantitative data on user experiences and preferences.

Stage 2: Define the Problem

In this stage, the insights gathered from the empathise phase are synthesized to define a clear and concise problem statement (Carlgren et al., 2016). This statement guides the following stages of the design thinking process. In this stage, similar observations and insights are grouped to identify patterns of themes. After, a problem statement that captures the primary user needs and challenges is formulated.

Stage 3: Ideate

The ideate stage generates broad ideas and solutions (Corrales-Estrada, 2020). This phase involves brainstorming sessions to foster creativity and innovation. Ideas from the brainstorming sections are recorded, and the most significant ones are identified and selected.

Stage 4: Prototype

The prototype stage involves creating tangible representations of selected ideas (Carlgren et al., 2016). Prototypes can be from simple sketches (low-fidelity prototypes) or detailed models (low-fidelity prototypes).

Stage 5: Test

The test stage involves evaluating the prototypes with real users to gather feedback and refine the solutions (Carlgren et al., 2016). Participants interact with the prototype website to assess it based on several usability principles. The user feedback is used to make recommendations for future modifications to the prototype. Feedback is usually based on user satisfaction and usability.

The design thinking approach stages, including their objectives and various activities, are shown in Table 3.1.

Table 3.1 Design Thinking Approach for this Study

Stage	Objective	Activities
Empathise	To understand the perceptions and experiences of stakeholders (educators and learners).	• Conduct Semi-Structure Interviews • Thematic Analysis • Themes input into Empathy Map
Define	From users ' perspectives, identify the issues to consider when developing the prototype website.	• Issues developed from Empathy findings in the Empathise Stage

Table 3.1 continued

Ideate	Suggest ideas for solving the problem.	• Develop solutions to the issues identified. • Formulate a prototype website to address the issues based on the solutions.
Prototype	To develop tangible and experienceable representations of the ideas.	• Develop a prototype website.
Test	Evaluate the prototype using potential users.	• Test the functionality and effectiveness of the prototype. • Evaluate the Website. • Feedback from end users. • Recommendations to improve the prototype.

ADDIE Model

The ADDIE model, an instructional design framework, consists of five phases: Analysis, Design, Development, Implementation, and Evaluation (Kim & Mun, 2021). It is one of the most used models for instructional design because it is simple yet highly effective. The model is often used to design organizational training and learning development programs. ADDIE model identifies learning needs in a structured way, ensuring all activities align with the learning goal. This integrated approach also assists in measuring learning effectiveness by clearly defining behaviours, knowledge, and skills (Kim & Mun, 2021; Patel et al., 2018). Each stage must be completed sequentially and carefully in the model before proceeding to the next. Hence, this study will focus on designing and developing a programming learning website by following the ADDIE model. In summary, the phases of the ADDIE Model applied to this study are presented in Table 3.2.

Table 1.2 ADDIE Model Approach for this Study

Phase	Definition	Tasks/Activity	Output
Analysis	The process of defining the learning environment	• Needs assessment. • An analysis of the learning environment • Task analysis	• Learner profile • Description of constraints

Design	The process of specifying how it is to be learned on the website	● Write objectives. ● Learning tools	● Measurable objectives ● Web-based platform
Development	The process of authoring and producing the materials	● Work with producers. ● Develop learning materials, flowcharts, and program.	● Sitemap ● Storyboard ● Script ● Exercises ● E-content package instruction
Implementation	The process of installing the project in the real-world context	● Students training ● Try-out	● Student comments and data
Evaluation	The process of determining the adequacy of the instruction	● Record time data. ● Interpret test results. ● Survey graduates.	● Recommendations ● Package report.

Aligning the ADDIE Model with Design Thinking

This study also employs the ADDIE Model, which consists of five (5) phases: analysis, design, development, implementation, and evaluation. While design thinking is iterative, the ADDIE model is linear. However, integrating the strengths of the two methodologies can assist instructional designers in developing innovative and impactful learning experiences.

a. Empathy and Analysis: The ADDIE model's analysis phase involves gathering information about learners' needs, goals, and constraints. Design thinking emphasises empathy, which involves understanding users' perspectives and needs. Combining these two steps helps instructional designers gain deep insights into the learners' context and challenges.

b. Problem Definition and Design: In the design thinking process, the define phase focuses on examining the problem in a user-centric manner. Integrating this step with the analysis phase of the ADDIE model assists instructional designers in defining clear problem statements and learning objectives that directly address learners' needs.

c. Ideate and Development: The design phase of the ADDIE model involves creating an instructional design plan, while design thinking enables ideation and brainstorming. Designers can develop innovative strategies addressing the defined problem and learning objectives by combining these two stages.

d. Prototype and Implementation: In the development step of the ADDIE model, instructional designers create the actual instructional materials based on the design plan. Design thinking encourages prototyping to gather feedback and refine solutions. Designers can create initial prototypes of the instructional materials, allowing for testing and iteration.

e. Test and Evaluation: The implementation stage of the ADDIE model involves deploying the instructional materials and facilitating the learning experience. Design thinking emphasizes testing and iteration to improve solutions. Thus, instructional designers can implement the instructional materials while continuously gathering feedback from learners and educators.

In this study, combining design thinking approach with the ADDIE model can provide a comprehensive framework that ensures both user-centred design and systematic development. It aims to enhance the user experience. The design thinking is aligned with ADDIE Model, as presented in Table 3.3.

Table 3.3 Design Thinking and ADDIE Model

Design Thinking Phase	ADDIE Phase
Empathise	Analysis
Problem Definition	Design
Ideate	Development
Prototype	Implementation
Test	Evaluation

Analysis Phase

The Analysis phase involves identifying and understanding the learning needs, goals, and audience characteristics (Patel et al., 2018). This phase includes conducting needs assessments, learner analysis, task analysis, and understanding the learning environment (Taqwa & Raupu, 2022). It ensures that the instructional design process is based on a clear understanding of what the learners need to achieve. Surveys, interviews, and assessments are often used to gather relevant data to guide the objectives and requirements for the instructional materials (Muslimin et al., 2017). This process ensures that the subsequent phases are aligned with the learners' needs.

Design Phase

In the Design phase, a detailed plan for the instructional materials is created (Patel et al., 2018). This involves outlining the content structure, choosing appropriate instructional strategies, and determining assessment methods (Muslimin et al., 2017). This includes developing course materials, multimedia components, and interactive elements (Spatioti et al., 2022). The design blueprint serves as a roadmap for developing the actual materials. Key considerations include the sequence of content, multimedia integration, and the overall user experience. The goal is to create a cohesive plan that facilitates effective learning and engagement.

Development Phase

During the development phase, the instructional materials are created based on the design specifications (Patel et al., 2018). This involves producing content, developing multimedia elements, and creating interactive components (Muslimin et al., 2017). It is a collaborative effort that may include subject matter experts, instructional designers, and technical developers. The focus is on translating the design plan into tangible materials that can be used for instruction. Prototypes and drafts are often reviewed and refined to ensure quality. In this study, the development phase in ADDIE model combines with the ideate phase of design thinking. Ideation generates innovative solutions to the defined problem (Corrales-Estrada, 2020). It involves brainstorming and exploring various ideas to find innovative approaches that address user needs.

Implementation Phase

In the implementation phase, the developed materials are delivered to the learners (Patel et al., 2018). This stage involves setting up the learning environment, providing access to the materials, and offering support. It facilitates a practical learning experience (Muslimin et al., 2017). Hence, logistical issues are addressed, and learners are guided on how to use the instructional materials. Also, feedback is collected to monitor the initial impact and identify any immediate adjustments needed. The implementation phase of ADDIE is combined

with design thinking's prototype stage. Prototyping involves building scaled-down versions of the website incorporating solutions from the Ideate phase (Corrales-Estrada, 2020). The prototype is tested in the evaluation phase.

Evaluation Phase

Evaluation involves assessing the effectiveness of the instructional materials (Patel et al., 2018). It includes formative and summative assessments to gather data on learner performance and satisfaction (Patel et al., 2018). Feedback from learners, observations, and performance metrics are used to evaluate the success of the instruction (Muslimin et al., 2017). The insights gained during this phase inform modifications and improvements, ensuring the instructional materials meet learning objectives and adapt to evolving needs. This iterative process enhances the overall quality and effectiveness of the instructional design.

Proposed Website

The prototype is an IoT programming learning website. The learning website aims to provide a platform for users to access educational content from any location. Learners can conveniently access resources, courses, and materials, allowing flexible learning schedules. Traditional face-to-face learning has been the dominant mode of education for centuries, but information technology has revolutionised the learning process. Online or web-based learning, often e-learning or distance learning, has become increasingly popular due to its efficiency, effectiveness, and flexibility. The website should provide a well-structured curriculum that covers all the essential aspects of IoT programming, from fundamental concepts to advanced topics. There should be provision or past examination questions for sessions and discussions about relevant material among learners. Additionally, the website should support different learning styles. Other website features include interactive learning resources and community support, enabling learners to share knowledge and experiences.

Data Collection

Data was gathered in two stages. The first stage included a semi-structured interview involving ten learners. The interview responses were used to capture their insights and requirements for the prototype. The responses were analysed using thematic analysis to identify relevant themes. The second stage involved an online survey to evaluate the prototype. In this stage, 30 respondents assessed the website based on usability principles and user experience. Finally, recommendations were made to improve the website based on the evaluation results.

Semi-Structured Interview

Semi-structured in-depth interviews are the most common data collection method in qualitative studies (Marvasti & Tanner,2020). It enables an understanding of other individuals' experiences and perspectives (Mashuri et al., 2022). A set of semi-structured, open-ended questions was used in interviews to allow free responses related to feelings, perceptions, and insights to emerge and some specific questions as prompts. Interviews were audio recorded and transcribed using Otter.ai (Otter.ai, 2020) before being analysed using the inductive content analysis approach. The semi-structured interview questions are presented in Table 3.4.

Table 3.4 Description of Interview Participants

Semi-Structured Interview Questions	
1.	**Heuristic Principles**
I.	Can you describe any difficulties you have encountered while using educational websites?
II.	How important is it for you that the website is easy to navigate? Can you give an example of a good experience?
III.	Have you ever felt lost or confused while using an online learning platform? What contributed to that feeling?

2.	**Usability Principles**
I.	What aspects of a website's design help you learn more effectively? (e.g., layout, colors, fonts)
II.	How do you prefer to find information or content on a learning website? (search bar, menu, recommendations)
III.	Can you recall when a website's design made it challenging to complete a task? What was frustrating about it?
3.	**User Satisfaction**
I.	What features of an online learning platform make you feel satisfied and motivated to use it?
II.	Can you share an experience where an educational website exceeded your expectations? What stood out to you?
III.	How do you feel about receiving feedback or support using a learning platform? What type of feedback is most helpful?
4.	**User Experience**
I.	How do you usually interact with online learning platforms? (e.g., desktop, mobile, tablet)
II.	What elements of a learning website make you enjoy using it and want to return? (e.g., interactive elements, ease of use)
III.	Can you describe any frustrations or barriers you have experienced that made you stop using a learning platform?

A total of 10 learners were engaged in the semi-structured interview, as illustrated in Table 3.5.

Table 3.5 Description of Interview Participants

Participant	Code	Gender	Educational Level	Course	Location
Learner 1	LNR1	Female	Undergraduate	Engineering	Malaysia
Learner 2	LNR2	Female	Undergraduate	Computer Science	Malaysia
Learner 3	LNR3	Male	Undergraduate	Information Technology	Saudi Arabia
Learner 4	LNR4	Male	Postgraduate	Computer Science	Saudi Arabia
Learner 5	LNR5	Female	Undergraduate	Computer Science	Malaysia
Learner 6	LNR6	Female	Postgraduate	Cyber Security	Saudi Arabia
Learner 7	LNR7	Male	Undergraduate	Engineering	Saudi Arabia
Learner 8	LNR8	Male	Undergraduate	Engineering	Saudi Arabia
Learner 9	LNR9	Male	Postgraduate	Engineering	Saudi Arabia
Learner 10	LNR10	Female	Undergraduate	Information Systems	Malaysia

Data Analysis

The transcript from the semi-structured interview will be analysed using thematic analysis to identify the common themes related to developing the IoT programming learning website. The thematic analysis follows a six-stage approach, as Braun and Clarke (2006) recommended. In the first stage, open descriptive codes are generated from the definitions and descriptions related to the IoT learning website. The second stage involved thematic analysis to identify common patterns from the coded data. The third stage involved organizing the phrases based on occurrence and commonality. The themes and sub-themes were developed from the thematic analysis results in the fourth stage. The fifth stage involved defining and naming each theme. Finally, the last stage includes a detailed narrative of each theme. The six stages of the thematic analysis are depicted in Table 3.6.

Table 3.6 Six Stages of the Thematic Analysis

	Description	**Activity**
Stage 1	Familiarisation with the Data	• Transcription: Transcribe all interview recordings verbatim. • Reading and Re-reading: Read through the transcripts multiple times to become familiar with the content. • Note-taking: Jot down initial thoughts and observations.

Table 3.6 continued

Stage 2	Coding the significant phrases	• Initial Codes: Generate initial codes by highlighting significant phrases or sentences related to the development of the learning website. • Consistency: Apply codes consistently across all transcripts to capture recurring concepts. • Software: Qualitative data analysis software is used to manage and organize the codes.
Stage 3	Identifying Themes	• Collate Codes into Themes: Group the codes into potential themes that represent broader patterns of meaning. • Thematic Maps: Create visual maps to organize and refine themes, showing how they relate.
Stage 4	Reviewing Themes	• Refinement: Review the themes to ensure they accurately reflect the data. Some themes may be combined, refined, or discarded. • Consistency Check: Ensure that themes are distinct and cover the relevant data comprehensively.
Stage 5	Defining and Naming Themes	• Clear Definitions: Define each theme clearly, detailing what aspect of the data it captures. • Naming: Assign concise, descriptive names to each theme.

Table 3.6 continued

Stage 6	Writing the Report	• Narrative: Write a detailed narrative for each theme, supported by interview quotes.

		• Coherence: Ensure the analysis tells a coherent story about the data and the research question.

The responses from the evaluation stage of the prototype website are analysed to identify the areas of improvement and make recommendations. The quantitative data collected from online surveys is analysed using statistical methods. This approach includes descriptive statistics, inferential statistics, and data visualization techniques using SPSS. It helps identify trends, and patterns in the data to inform decisions about website improvement.

Ethical Issues

The participant information sheet and consent forms were developed to inform and seek consent from participants.

Summary of the Chapter

The methodology chapter of this study outlines the research approach, paradigms, design, and data collection methods employed to understand and enhance user experience in developing an IoT programming learning website. The constructivist paradigm, emphasizing the subjective interpretation of reality and the importance of context, was selected for its alignment with qualitative research and the human-centred design thinking approach. This chapter comprehensively details the stages of the design thinking process: empathise, define, ideate, prototype, and test, underscoring the iterative nature of creating innovative solutions grounded in user feedback.

The research design integrates the ADDIE model, a linear instructional design framework encompassing analysis, design, development, implementation, and evaluation phases, with the iterative stages of design thinking. This integration aims to enhance instructional materials' effectiveness by ensuring a user-centred approach throughout the development process. The ADDIE model's structured approach aligns with the empathy and analysis phases of design thinking, aiding in thoroughly understanding learners' needs and challenges. Subsequently, the ideation and development phases merge, fostering the creation of innovative instructional strategies and materials.

Data collection was done in two stages: semi-structured interviews and online surveys. The semi-structured interviews involved ten learners and aimed to gather qualitative insights into their experiences and requirements. Following Braun and Clarke's six-stage approach, these interviews were analysed using thematic analysis to identify recurring themes and patterns. The second stage involved an online survey of 30 respondents to evaluate the prototype website based on usability principles and user experience, providing quantitative data analysed using statistical methods.

The chapter also discusses the ethical considerations, ensuring participants' informed consent and the confidentiality of their responses. Integrating qualitative and quantitative methods, guided by the constructivist paradigm and the ADDIE model, aims to create a comprehensive and user-centred learning website. The study's iterative and structured methodology ensures that the developed instructional materials effectively address learners' needs, providing an enhanced learning experience in IoT programming.

In conclusion, the methodology chapter demonstrates a robust approach to developing educational websites, integrating human-centred design principles with systematic instructional design frameworks. This approach ensures the creation of a learning platform that is not only pedagogically sound but also suited to the needs and experiences of its users. The combination of design thinking and the ADDIE model provides a balanced methodology that enhances the overall quality and effectiveness of the educational website, ensuring its relevance and impact on learners' experiences.

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RESULTS

Introduction

The chapter explores applying a design thinking approach to enhance an IoT learning website prototype. Design thinking, emphasising empathy and iteration, is used to develop innovative solutions for the website. The study aims to address common issues identified by learners through a human-centred problem-solving process including brainstorming sessions. The chapter presents insights from semi-structured interviews with learners and thematic analysis results. Also, the chapter includes an empathy map, defined issues, proposed solutions, and an affinity diagram. The findings are presented in five stages, focusing on user experience and feedback to improve the website's usability and engagement.

Aligning the Design Thinking Approach with ADDIE Model

In this study, design thinking is a human-centred problem-solving approach emphasising empathy and iteration to develop innovative solutions to improve the proposed website (Corrales-Estrada, 2020). It helps designers provide innovative solutions through several steps (Suratno & Shafira, 2022). This study also employs the ADDIE Model, which consists of five (5) phases: analysis, design, development, implementation, and evaluation. While design thinking is iterative, the ADDIE model is linear. The two approaches are integrated to develop more innovative and impactful learning experiences. The findings of each stage as illustrated in Table 4.1 are reported in five sections.

Table 4.1 Design Thinking and ADDIE Model

Design Thinking Phase	**ADDIE Phase**
Empathise	Analysis
Problem Definition	Design
Ideate	Development
Prototype	Implementation
Test	Evaluation

Stage 1: Empathise and Analyse

Ten (10) learners were interviewed in this stage to identify issues with existing educational in this context, and the relevant responses are presented in Table 4.2.

Table 4.2 Semi-Structured Interview Questions and Responses

Semi-Structured Interview Questions	
Question	**Responses**
Heuristic Principles	
IV. Can you describe any difficulties you have encountered while using educational websites?	"Difficulties usually arise from poorly organized content. Easy navigation is crucial; for example, Coursera does a good job with their clear course pathways." (Learner 3)

Table 4.2 continued

V.	How important is it for you that the website is easy to navigate? Can you give an example of a good experience?	"Easy navigation is crucial for me... It made the learning process smooth and enjoyable." (Learner 1) "It is important for me that the website is easy to navigate. I had a great experience with a site that used clear, labeled sections and a consistent menu layout." (Learner 2)
VI.	Have you ever felt lost or confused while using an online learning platform? What contributed to that feeling?	Yes, I've felt lost when the website's structure is not intuitive. I could not figure out how to go back to a previous lesson because there were no clear navigation links. The whole experience was confusing." (Learner 1)
		(a) Usability Principles
IV.	What aspects of a website's design help you learn more effectively? (e.g., layout, colors, fonts)	"Consistent use of fonts and colors helps me learn better. I prefer using a combination of the menu and search bar." (Learner 4) "Aesthetic, minimalist design with readable fonts helps me learn effectively. I prefer using the menu for navigation." (Learner 10)
V.	How do you prefer to find information or content on a learning website (search bar, menu, recommendations)?	"I appreciate clean layout with clear headings. I often use the search bar to find content." (Learner 5) "A simple, elegant design with good use of white space helps me concentrate. I prefer browsing through a menu." (Learner 6)
VI.	Can you recall when a website's design made it challenging to complete a task? What was frustrating about it?	"… a site that used too complex menus and lacked a search function. It was hard to complete assignments because I could not easily find the necessary materials. I spent too much time navigating instead of learning." (Learner 5)
		(b) User Satisfaction
IV.	What features of an online learning platform make you feel satisfied and motivated to use it?	"…features like progress tracking and immediate feedback on quizzes motivate me to learn." (Learner 7) "I find it satisfying when I can customize my learning and see my achievements." (Learner 9)

Table 4.2 continued

V.	Can you share an experience where an educational website exceeded your expectations? What stood out to you?	*"I feel satisfied when the website provides instant feedback on quizzes and assignments. It motivates me to continue learning." (Learner 7)*
VI.	How do you feel about receiving feedback or support using a learning platform? What type of feedback is most helpful?	*"Receiving feedback is essential for me." (Leaner 4)* *"... detailed feedback on assignments is constructive because it shows me exactly where I went wrong and how to improve." (Learner 6)*

		"Instant feedback on quizzes is usually beneficial for immediate learning." (Learner 10)
(c)	**User Experience**	
I.	How do you usually interact with online learning platforms (e.g., desktop, mobile, tablet)?	*"I interact using my mobile phone. Quick access to resources and a user-friendly interface is key for me." (Learner 1)* *"I use my laptop for learning. Websites that have smooth navigation and minimal load times are my favorite." (Learner 2)*
II.	What elements of a learning website make you enjoy using it and want to return (e.g., interactive elements, ease of use)?	*"Interactive elements like quizzes, forums, and coding challenges keep me engaged." (Learner 2)* *"I like using platforms that are easy to navigate and have a nice appealing design. It makes my learning enjoyable." (Learner 5)*
III.	Can you describe any frustrations or barriers you have experienced that made you stop using a learning platform?	*"I have abandoned platforms with slow load times and confusing interfaces." (Learner 4)* *"a lack of clear instructions or support." (Learner 5)* *"If I cannot easily find help when I am stuck, it affects my learning progress." (Learner 9)*

Thematic Analysis

After the interview, a thematic analysis was employed. The thematic analysis identified six themes and twenty-one sub-themes from the semi-structured interview are presented in Table 4.3. The themes six identified included navigation and layout, design elements, complex menus, and lack of a search function. There are three themes, each having three sub-themes. User experience has six sub-themes, feedback has three sub-themes, and device compatibility has two.

Table 4.3 Identified Themes and Sub-Themes from Thematic Analysis

Themes	**Sub-Themes**
Navigation and Layout	• Easy Navigation • Cluttered Layouts • Web Structure
Design Elements	• Minimalist and Consistent Design • Search Functionality • Menu Organisation
Complex Menus and Lack of Search Function	• Complicated Menus • Absence of Search • Disorganized Menu Structures

User Experience	• Progress Tracking • Responsive Feedback • Web Responsiveness • Interaction Elements • User Engagement • User-Friendly
Feedback	• Detailed Feedback • Immediate Feedback • Positive Feedback

Table 4.3 continued

Device Compatibility	• Compatible Devices • Mobile Devices

Navigation and Layout

The thematic analysis confirmed that navigation and layout significantly impact website user experience. Easy navigation ensures users can swiftly find information, enhancing their interaction. Conversely, cluttered layouts overwhelm users and hinder information retrieval. A well-structured web layout logically organizes content, guiding users seamlessly through the site.

Design Elements

The findings show that design elements are pivotal in website usability and aesthetics. Minimalist and consistent design principles create a cohesive and visually pleasing interface, reducing cognitive load. Search functionality enables efficient content retrieval, enhancing user satisfaction. Thoughtfully organized menus streamline navigation, ensuring intuitive access to information.

Complex Menus and Lack of Search Function

Results identified that complex menus with intricate hierarchies or unclear categories confuse users, complicating navigation. The absence of a search function impedes users from quickly locating specific information, leading to frustration. Disorganized menu structures further exacerbate navigation challenges, undermining the user experience.

User Experience

The analysis confirmed that user experience is essential to user interaction with websites. Progress tracking features inform users about their current activities or courses, fostering transparency and motivation. Responsive feedback, such as visual or auditory cues, immediately acknowledges user actions, enhancing usability. Web responsiveness ensures seamless performance across devices, accommodating diverse user preferences. Intuitive interaction elements, including buttons and forms, facilitate smooth user engagement. Engaging content and interactive features promote sustained user interest and interaction. Likewise, a user-friendly interface adheres to usability principles, aligning with user expectations to facilitate intuitive and enjoyable interactions. Figure 4.1 illustrates the six themes and their sub-themes.

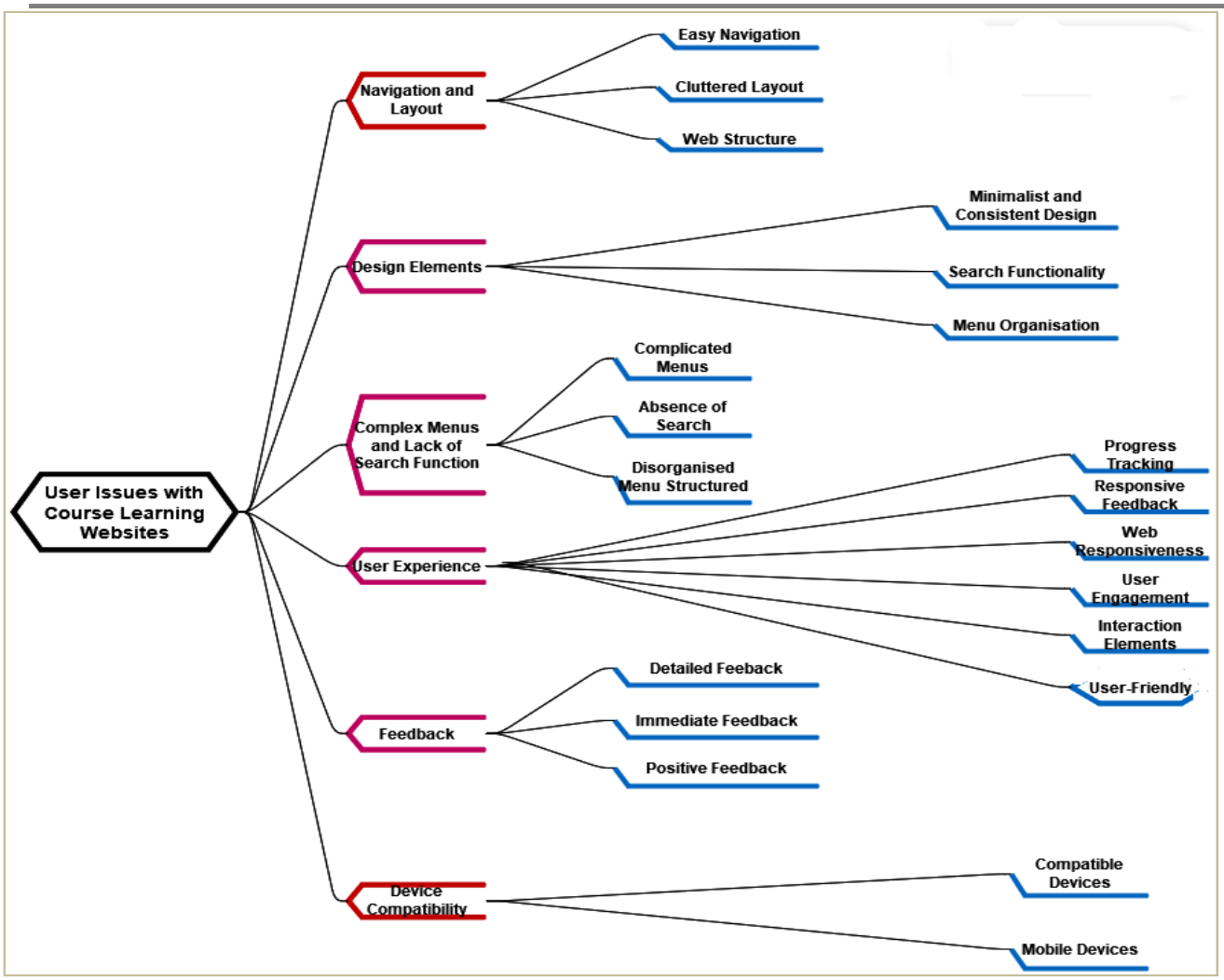

Figure 4.1 Identified Themes and Sub-Themes from Thematic Analysis

Empathy Map for Learners

The empathy map provides insights about what the user says, thinks, feels, and does.

What Learners Say:

"I have often struggled with navigation on educational websites."

"Easy navigation is crucial for me."

"A clean and minimalist layout helps me focus better."

"Features like progress tracking and immediate feedback on quizzes keep me motivated."

"I once used a platform with a very responsive support system."

"I mainly use my desktop for online learning."

What Learners Think:

- The website should be easy to navigate with clear sections and intuitive layouts.
- A minimalist and consistent design is essential for effective learning.
- Immediate and detailed feedback is crucial for motivation and improvement.

- The ability to adapt learning paths and track progress is important.
- Responsive support systems enhance the learning experience.
- The design should minimize errors and confusion.

What Learners Do

- Use search bars and well-organized menus to find content quickly.
- Abandon platforms with slow load times and confusing interfaces.
- Rely on desktop computers for most online learning activities, but also use tablets and mobile devices for convenience.
- Engage with interactive elements like quizzes, forums, and coding challenges.

What Learners Feel

- Frustrated by cluttered layouts, complex menus, and lack of clear navigation.
- Satisfied and motivated by platforms that provide immediate feedback and progress tracking.
- Engaged and focused when using platforms with a clean, minimalist design.
- Confident and encouraged when receiving detailed feedback and responsive support.

Table 4.4 Empathy Map

Learners' Thoughts and Feelings	**Learners' Actions and Behaviours**
Think	**Do**
The website should be easy to navigate.	Use search bars and well-organized menus.
A minimalist design aids learning.	Abandon platforms with slow load times.
Immediate feedback is crucial.	Rely on desktop computers for learning.
Customisable learning paths are vital.	Engage with interactive elements.
Feel	**Say**
Frustrated by cluttered layouts.	"I've often struggled with navigation."
Satisfied by progress tracking.	"Easy navigation is crucial for me."
Engaged by clean designs.	"A clean and minimalist layout helps."
Confident with detailed feedback.	"Features like progress tracking..."

In summary, the process and results of the empathise (Design Thinking) and analysis stage (ADDIE Model) are summarised in Table 4.5.

Table 4.5 Empathy Map

Design Thinking		ADDIE Model	
Participants	10 learners	Target Audience	Learners
Interview	Semi-structured Interview	Needs Assessment	Semi-structured Interview
Analysis	Thematic Analysis	Content Analysis	Thematic Analysis
		Constraints	Budgetary Constraints. Time Frame

Table 4.5 continued

Output	Identified Themes and Sub-Themes from Thematic Analysis. Empathy Map	Findings	Identified Themes and Sub-Themes from Thematic Analysis

Stage 2: Define the Problem and Design

The ten learners noted and analysed the problems identified for more insights. Hence, nine issues were clearly defined. Based on the issues identified, a user-friendly interface for the online platform will be designed to address the issues.

Navigation Issues

This was identified as one of the issues, as some respondents reported difficulty navigating educational websites due to cluttered layouts. Other respondents had to click multiple pages to find a specific subject or tutorial. Additionally, it was difficult for some respondents to return to previous pages when navigating an educational or online course website. This inconvenience can lead to disengagement, especially for learners who prefer quick access to information. It is essential for users to be able to easily navigate through a website.

Complex Menus and Lack of Search Function

Respondents reported difficulty completing tasks due to complex menus and the absence of a search function. This complexity affects learners' ability to find necessary materials quickly. Hence, they may have an unpleasant experience with online course websites, discouraging them from continuing to use them. Furthermore, users may feel frustrated when using a learning website with limited or no search functions. Seach helps with navigation and allows learners to locate course resources or materials quickly.

Website Interface

Some of the web interfaces needed to be more straightforward. Others found that the online interface had inconsistent design elements that can distract learners. Furthermore, the interface was not structured and easy to locate. Hence, it was difficult for respondents to locate specific courses or resources and concentrate while learning. Moreover, some users need help with successfully logging into their accounts.

Lack of Clear Instructions on the Website

Learners revealed that some course websites failed to provide clear instructions for users, essential for smooth learning progress. Unclear instructions can make learners become stuck and demotivated, negatively impacting their online educational experiences.

Lack of Customisation and Progress Tracking

Some course websites lacked features like progress tracking and the customization of learning paths. Without these tools, learners may feel disconnected from their learning experience and less motivated to continue

learning. Hence, customising website based on user preferences makes their learning experience more enjoyable.

Non-existing or Unresponsive Support

In some cases, respondents found that the online course websites lacked online support. Some identified the problem of unclear instructions and lack of accessible support. Other respondents complained about non-functional or unresponsive support systems on these sites. The support systems do not provide quick and helpful responses. Hence, users may get stuck using the site and require assistance or help guides.

Feedback Issues

Lack of detailed and instant feedback on assignments and quizzes. Constructive feedback is essential for effective learning. Detailed and instant feedback helps learners understand their mistakes and make improvements promptly. It promotes a more exciting online educational experience.

Compatibility Issues with Device

Some compatibility issues included the website display on different screens or devices. Learners reported switching between devices, which can disrupt their learning experience. Notably, users identified difficulties viewing some learning course websites on mobile devices.

Slow Load Times

Respondents identified that some websites took a long time to load, discouraging them from using them. Others abandoned the websites, and it took longer to course content and resources. They expect a seamless and efficient experience with minimal delays. Such delays can frustrate learners and make them abandon the online course. Furthermore, websites that take longer to load will affect users' study patterns because they may take longer to complete quizzes, assignments, and courses.

An affinity diagram visualises and organises the identify issues into a relationship (Widjaja & Takahashi, 2016). The diagram in Figure 4.2 illustrates excellent issues identified by users related to the issues with online websites for learning.

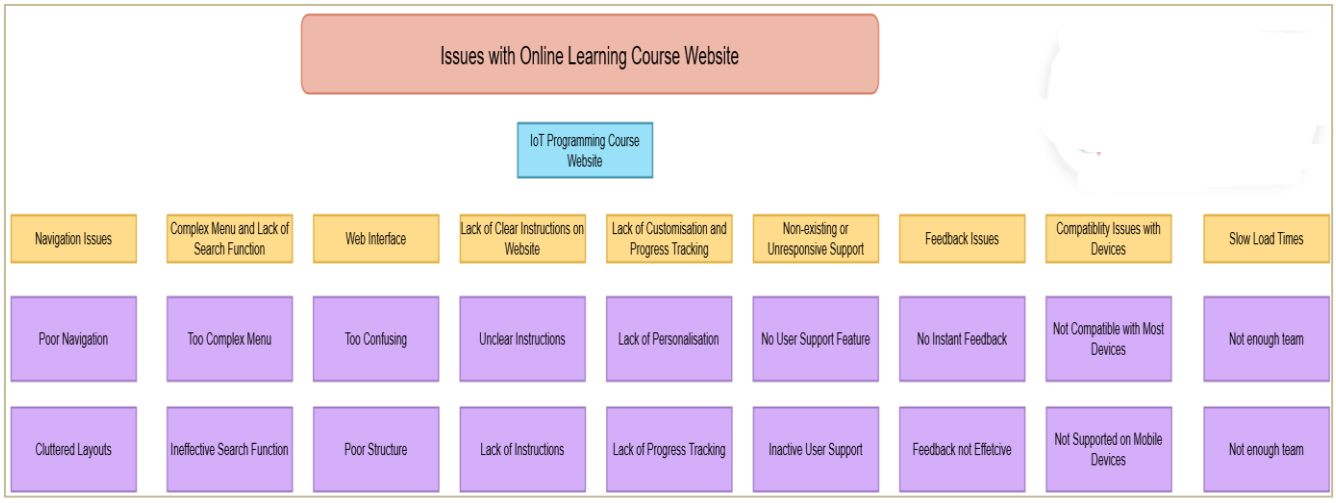

Figure 4.2 Affinity Diagram

In the ADDIE model's design stage, addressing the identified issues involves creating a user-friendly online learning platform that streamlines navigation with a clean layout and intuitive pathways, simplifies menu structures, and includes a robust search function. Consistent and straightforward web interfaces should be ensured, with clear instructions and easy login processes. Customisation and progress tracking features must be integrated to enhance learner engagement and accessible and responsive support systems. Detailed and instant

feedback mechanisms should be included, and the platform should be optimised for compatibility with various devices and fast load times to provide a seamless, efficient learning experience.

Stage 3: Ideate and Development

The ideate stage generates broad ideas and solutions (Corrales-Estrada, 2020; Tschimmel, 2012). This phase involves brainstorming sessions to foster creativity and innovation; the most significant ones are identified and selected. The ten learners were involved in a brainstorming session to address the problem based on meaningful solutions. The solutions for designing the prototype of an enhanced IoT programming website are presented in Table 4.6.

Table 4.6 Proposed Solutions to Identified Issues

Identified Issue	**Description**	**Proposed Solution**
Navigation Issues	Users report having to click through multiple pages to find specific subjects or tutorials. Users are challenged to return to previous pages, causing frustration and disengagement among learners who want to access course materials and resources quickly.	• Implement a streamlined layout with clear categories and subcategories. The pages should not be cluttered. • Incorporate navigation that allows users to backtrack quickly. • Introduce a search bar to facilitate faster access to specific content.

Table 4.6 continued

Complex Menus and Lack of Search Function	The complexity of menus and the absence of a search function significantly impede learners' ability to find necessary materials quickly. This complexity contributes to an unpleasant user experience on online course websites.	• Simplify menu structures, reducing the number of nested options. • Include a robust search function with filters and advanced search options. Provide a user-friendly sitemap to offer an overview of all available content.
Website Interface	Confusing and inconsistent web interfaces can distract and strain learners, making locating specific courses or resources difficult. An inconsistent design can also hinder learners' ability to concentrate.	• Standardize design elements across the website for a cohesive look and feel. • Use clear, distinct visual cues and labels for different sections and resources. • Conduct user testing to refine the interface based on actual user feedback.
Lack of Clear Instructions on the Website	Learners often need clarification on instructions, which are crucial for ensuring smooth progress. This lack of clarity can frustrate learners, adversely affecting their online educational experiences.	• Provide clear, concise instructions for navigating the site and completing tasks. • Use tooltips, help icons, and tutorial videos to guide users through complex processes.

		• Offer an FAQ section and step-by-step guides for common issues.
Lack of Customisation and Progress Tracking	The absence of features like progress tracking and customisable learning can make learners feel disconnected and less motivated to continue their education.	• Introduce customizable learning tailored to individual learning goals. • Implement progress-tracking tools that visually display learners' progress and milestones. • Provide personalized recommendations based on learners' past activities and preferences.

Table 4.6 continued

Non-existing or Unresponsive Support Systems	A lack of accessible support and unresponsive systems can leave learners feeling unsupported.	• Develop a responsive support system with live chat, email support, and a ticketing system. • Offer a comprehensive knowledge base and community forums to support learners.
Feedback Issues	The lack of detailed and instant feedback on assignments and quizzes hampers learners' ability to understand their errors and improve.	• Provide automated feedback for quizzes and assignments with detailed explanations. • Enable instructors to give personalised feedback through audio or video comments. • Implement peer review systems to facilitate constructive feedback among learners.
Compatibility Issues with Devices	Compatibility issues with different screens or devices can disrupt learners' experiences, as they may need to switch between devices frequently.	• Ensure the website is fully responsive and optimized for various devices and screen sizes. • Conduct extensive testing across multiple browsers and operating systems. • Develop a website that is compatible with mobile devices.
Slow Low Times	Slow load times can discourage learners from using educational websites, leading to the abandonment of the platform.	• Optimise website performance by minimizing the use of heavy graphics and scripts.

In the ADDIE model's development stage, proposed solutions to the identified issues in Table 4.5 are highlighted in Table 4.6 to enhance the online learning platform. A streamlined layout with clear categories

and backtrack navigation will be developed for navigation issues, as well as a search bar for quick access to content. To address complex menus and lack of search functionality, simplified menu structures and a robust search function with advanced options will be introduced, accompanied by a user-friendly sitemap. A standardized website interface with cohesive design elements and user testing will ensure consistency and ease of use. Furthermore, clear instructions will be provided through concise guides, tooltips, and tutorial videos, supplemented by an FAQ section and step-by-step guides.

Moreover, personalised learning paths and progress-tracking tools will be implemented to motivate learners and personalise their experiences. A responsive support system featuring live chat, email, ticketing, a knowledge base, and community forums will offer comprehensive assistance. Detailed and instant feedback mechanisms for quizzes and assignments, including automated feedback and peer review systems, will be integrated to enhance learning. Ensuring full responsiveness and compatibility across various devices and browsers will address device compatibility issues. Finally, improving website performance by reducing heavy graphics and scripts will improve load times, ensuring a seamless and efficient user experience. These solutions aim to create a user-friendly, engaging, and effective online learning environment. The next stage involves proposing a prototype to capture all the data and proposed solutions.

Proposed Prototype for the IoT Learning Website

A prototype for the IoT learning website is proposed based on the solutions to address the common issues identified by respondents. The prototype aims to provide an engaging, user-friendly website with an enjoyable learning experience. The features of the proposed prototype are shown in Table 4.7.

Table 4.7 Features of the Proposed Prototype

Web Page	**Description**	**Features**
Home Page	The home page is the main page for the learning platform. It should be interactive, easy to navigate, and have links to other website sections. The	• Navigation Bar includes a simple and organized menu with transparent sections. • Search Bars • Display of all the available courses.

Table 4.7 continued

Home Page		• Direct links to tutorials and resources. • User Dashboard: User progress, current course, resource access, and personalized learning.
Course Catalogue	A comprehensive and well-organized catalogue of available courses and relevant resources.	• Filters options for topic, difficulty level, duration, and instructor. • Each course card will include a title, brief description, and duration. • Detailed information about the course, including syllabus, instructor bio, reviews, and enrolment.
Course Interface	Information and resources for courses learners have enrolled in.	• Visual progress bar showing completion status.

		• Sidebar with sections for each module and lesson. • Navigation for easy backtracking. • High-quality video player, resources, quizzes, and assignments. • Integrated forum for each course, enabling learners to interact with other learners and instructors.
User Dashboard	A personalised space for users to track their learning journey and access customized content.	• Basic user information and settings. • Visual representation of ongoing courses and completed milestones. • Calendar view of assignment due dates and scheduled webinars. • Personalized recommendations with suggested courses and resources based on user interests and progress.

Table 4.7 continued

User Support	A robust support system to assist users with any issues or questions they may have.	• Real-time support from knowledgeable staff. • Knowledge Base, including tutorials and FAQs.
Mobile Compatibility	Ensuring the website is fully functional and optimized for mobile devices.	• Fluid layouts that adapt to different screen sizes and orientations, including mobile devices.

Stage 4: Prototype and Implementation

The website was developed using appropriate web development technologies. Interactive features were implemented on the website, including solutions to the issues identified by learners. In design thinking, this is the prototype and implementation stages in the ADDIE model. Figure 8 displays the IoT programming course prototype.

Figure 4.3 Prototype of Website

Twelve website principles and rules were applied to the development of the website, as shown in Table 4.8.

Table 4.8 Features of the Prototype

Usability Principle and Rules	**Features**
Understandability and Clarity	Straightforward Navigation: A top navigation bar with clear labels for each main section ("Home," "Courses," "Contact"). Logical Content Organization: Arranging course content chronologically or thematically, with headings and subheadings for easy scanning. Interactive FAQs: An FAQ section with expandable sections and precise answers to commonly asked questions.
Accessibility	High Contrast Text: Black text on a white background ensures readability for users with visual impairments. Alt Text for Images: Descriptive alternative text for images that conveys the image's content to screen readers for visually impaired users.
Consistency	Colour Palette: Using a consistent colour scheme throughout the website, including primary and secondary colours, for a cohesive brand identity. Font Styles: Maintaining a consistent font family and size for headings, body text, and buttons to create a unified visual experience. Button Styles: Using the same style (rounded corners, blue background) for all call-to-action buttons to ensure users recognize them easily.
Feedback and Responsiveness	Progress Bars: Progress bars for lengthy video lectures indicate the remaining time. Confirmation Messages: A message confirming successful course enrolment or form PR assignment submission. Interactive Quizzes: Instant feedback on quiz answers, allowing users to learn from mistakes immediately.
User Control and Freedom	Multiple Paths: It allows learners to choose from programmer's courses or an engineer's experience. Downloadable Materials: Providing downloadable PDFs of lecture notes or presentations for offline access. Bookmarking Functionality: A booking feature that allows users to save their progress and quickly return to unfinished sections.

Table 4.8 continued

Error Prevention and Handling	Form Validation: Real-time form validation highlighting missing information or incorrect formats before submission. Confirmation Before Deletion: A confirmation pop-up before users delete essential course materials, preventing accidental loss. Detailed Error Messages: Informative examples explain and offer solutions instead of generic error codes.

Efficiency of Use	Fast Loading Times: Optimizing images and code for fast loading speeds across various devices. Search Functionality: A robust search bar that allows users to find specific course content or topics quickly. Keyboard shortcuts for common actions like navigating between modules or taking notes.
Aesthetic and Minimalist Design	Whitespace Utilisation: Using whitespace improves visual clarity, avoids clarity, and avoids overwhelming users. High-Quality Images: Using professional-looking images and icons complementing the website's overall design aesthetic. Limited Animations: Sparing use of animations that do not directly contribute to the user experience or distract from the learning content.
Recognition Rather Than Recall	Breadcrumbs: A breadcrumb navigation bar at the top of the page shows users their current location within the course structure. Iconography: Using clear and consistent icons for standard functionalities, such as play buttons for videos and download icons for downloadable materials.
Flexibility and Adaptability	Responsive Design: A website that automatically adjusts its layout for optimal viewing on any device (desktop, tablet, mobile). Multiple Difficulty Levels: Offering courses at different difficulty levels to cater to users with varying levels of prior knowledge.

Table 4.8 continued

Flexibility and Adaptability	Personalised Recommendations: Additional courses should be recommended based on users' previous learning activities and interests.
Visibility of System Status	Loading Spinners: While the course video loads, display a loading spinner to inform users that the system is working. Submission Confirmation: After submitting a form, display a message indicating whether the submission was successful. Maintenance Mode Page: A Maintenance Mode Page is a temporary placeholder displayed to visitors when your website is undergoing maintenance, updates, or experiencing technical difficulties.
Image Placement	Course Featured Image: Large image at the top, visually representing the course content. Images Throughout Course: Relevant images placed near related text for better understanding.

Stage 5: Testing and Evaluation

This stage is referred to as testing in design thinking and evaluation in ADDIE model. The test or evaluation stage involves evaluating the prototypes with real users to gather feedback and refine the solutions (Carlgren et al., 2016; Nadiyah & Faaizah, 2015). Participants interact with the prototype website to assess it based on several usability principles. The user feedback is used to make recommendations for future modifications to

the prototype. Feedback is based on user satisfaction and usability. The matric for the evacuation of usability based on Nielsen model is depicted in Figure 4.4 (Puspitasari et al., 2023; Nielsen & Landauer, 1993).

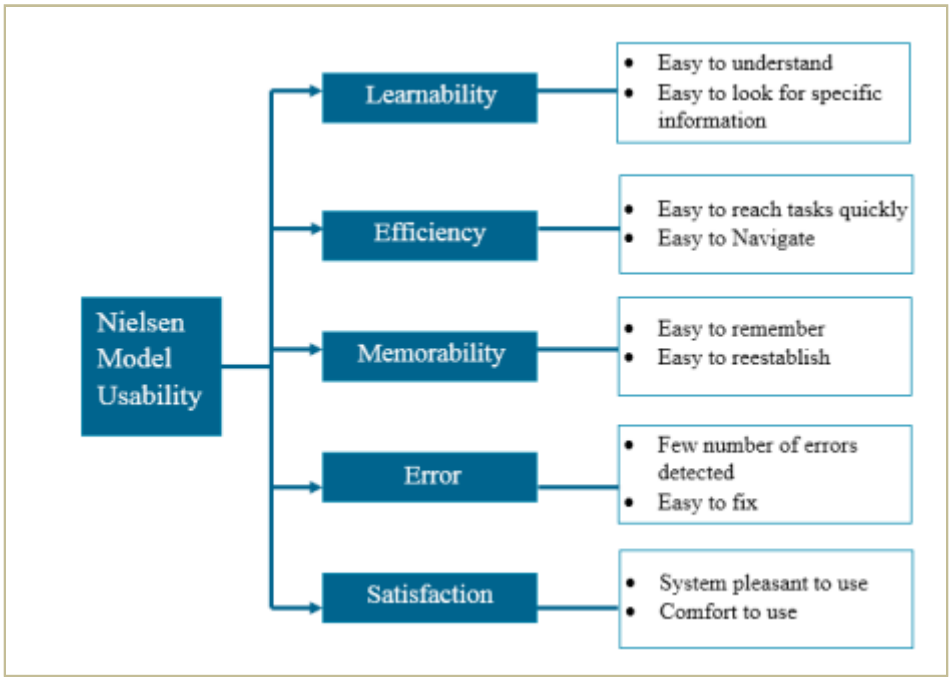

Figure 4.4 Matric to indicate overall usability based on Nielsen Model

Findings

The demographic analysis of the 29 survey participants reveals that 54% were male and 46% were female. Age distribution in Figure 4.6 showed a diverse range, with 17% aged 18-24, 34% aged 25-34, 28% aged 35-44, 14% aged 45-54, and 7% aged 55-64. Educational backgrounds for participants including 10% holding a high school diploma, 17% an associate degree, 41% a bachelor's degree, 24% a master's degree, and 7% a doctorate. Most participants had a bachelor's or master's degree. Most respondents (45%) had 3-6 months of experience with E-Learning Websites, followed by those with 1 year and above (17%), 9-12 months (14%), 1-3 months (14%), and 6-9 months (11%) of experience. Table 4.9 summarises the demographic information of the 29 respondents.

Table 4.9 Demographics of Study Participants

Category	Sub-category	Frequency	Percentage
Gender	Male	16	54%
	Female	12	46%

Table 4.9 continued

Age Group	18-24	5	17%
	25-34	10	34%
	35-44	8	28%
	45-54	4	14%
	55-64	2	7%

Education	High School	3	10%
	Associate degree	5	17%
	Bachelor's Degree	12	41%
	Master's Degree	7	24%
	Doctorate	2	7%
Experience with E-Learning Websites	1-3 Months	4	14%
	3-6 Months	13	45%
	6-9 Months	3	11%
	9-12 Months	4	14%
	1 Year and Above	5	17%

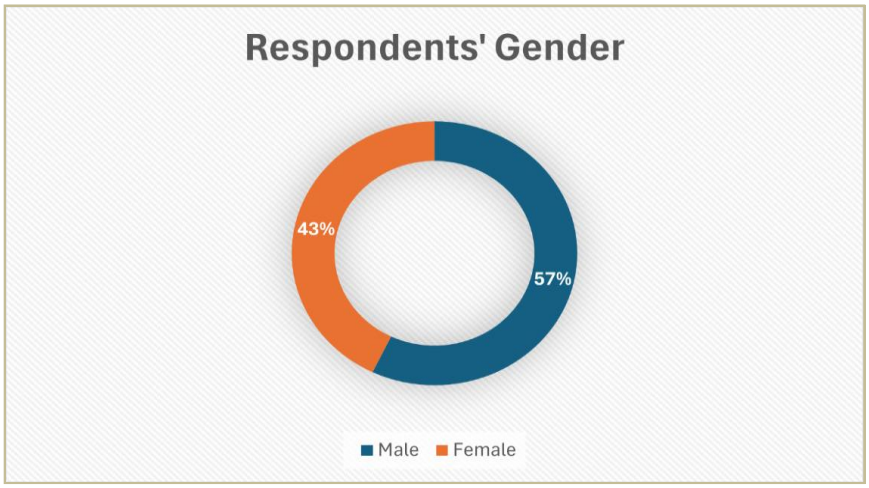

Figure 4.5 Gender of Respondents

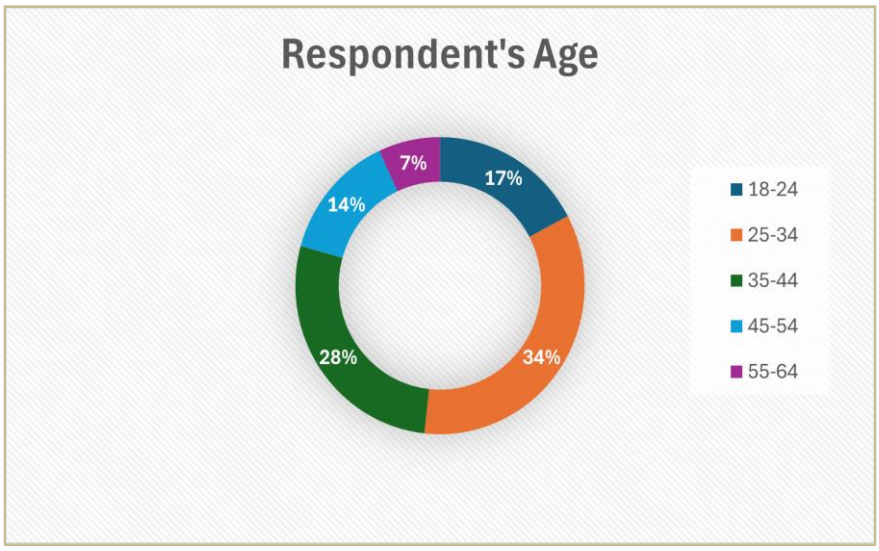

Figure 4.6 Age of Respondents

Section 1: Understandability and Clarity

Regarding understandability and clarity, most respondents found navigation easy (34%), others reported it as neutral (10%) and difficult (7%). Most respondents reported that the instructions were clear (52%), and the content was organised (45%). Furthermore, the website guide was found to be effective (72%) by most respondents and the modules were well delineated (72%).

Section 2: Accessibility

In the Accessibility section, the top responses for General Accessibility indicated that 52% of participants found the website fully accessible with their current devices and technologies, while 34% rated it as accessible. Regarding the use of assistive technologies, 41% of respondents encountered no difficulties, and 34% experienced only a few difficulties. For Specific Accessibility Features, 41% of participants rated the colour contrast as very appropriate, and 38% as appropriate. In terms of alt text for images, 69% confirmed its presence. Finally, for keyboard navigation, 38% found the website fully navigable, and 34% rated it as navigable.

Section 3: Consistency

In terms of design consistency, 38% of respondents rated the website as very consistent, and another 38% rated it as consistent. Regarding navigation layouts, 31% found them very intuitive, while 34% found them intuitive.

Section 4: Feedback and Responsiveness

For interaction feedback, 45% of participants reported always receiving immediate and clear feedback, and 31% often received it. Concerning confirmation clarity, 38% found it very clear, and another 38% found it clear.

Section 5: User Control and Freedom

In terms of control over the learning environment, 41% of respondents felt they had full control, and 38% felt they had control. For undo actions and customization, 34% found it very easy, and another 38% found it easy. Regarding course section accessibility, 41% rated it as very accessible, and 34% rated it as accessible.

Section 6: Error Prevention and Handling

When evaluating error prevention, 38% of participants found it very effective, and 34% found it effective. Regarding the clarity of error messages, 34% rated them as very clear, and 41% as clear. For helpful resources, 34% found them very helpful, and 38% found them helpful.

Section 7: Efficiency of Use

Regarding overall efficiency, 41% of users found the website very efficient, and 38% found it efficient. For load times, 41% rated them very short, and another 38% rated them short. Concerning shortcuts, 62% of participants noticed and used them.

Section 8: Aesthetic and Minimalist Design

In terms of visual appeal, 38% of respondents found the design very appealing, and another 38% found it appealing. Regarding design focus, 38% felt it was very focused, and another 38% found it focused.

Section 9: Recognition Rather Than Recall

For memory load minimization, 38% of participants felt the website performed very well, and another 38% felt it performed well. Concerning information recall, 45% of users never had to remember information from one part of the dialogue to another, and 31% had to do so sometimes.

Section 10: Flexibility and Adaptability

Regarding user flexibility, 41% found the website very flexible, and 34% found it flexible. For tailoring actions, 38% found it very easy, and another 38% found it easy. In terms of personalized learning experiences, 41% of users felt the website provided these opportunities very much, and 34% felt it provided them much.

Section 11: Visibility of System Status

In terms of feedback timeliness, 38% of respondents found it very timely, and another 38% found it timely. Regarding status information, 41% of participants always felt informed about what was happening while using the website, and 34% often felt informed.

Section 12: Image Placement

Regarding the effectiveness of image placement, 38% of participants found it very effective, and another 38% found it effective. Concerning the placement of important photos and content, 41% rated it very well, and 34% rated it well.

Section 13: Standards

For design conventions, 38% of respondents felt the website followed them very well, and another 38% felt it followed them well. In terms of interaction consistency, 38% found it very consistent, and another 38% found it consistent.

Specific Issues Encountered

The participants commented on issues they encountered while using the websites.

a. **Load Times:** Several participants (1, 9, 13, 19) reported slow load times for educational modules and videos.

b. **Navigation and Accessibility:** A few participants (2, 4, 7, 23) mentioned difficulties with navigation, especially for assistive technology users.

c. **Content and Links:** Issues like broken links (5, 15), confusing layout (21), and overwhelming information (10) were noted by some users.

d. Other issues included mobile accessibility (12), login problems (17), and inconsistent design (25). One respondent mentioned encountering an issue with the load time on one of the educational modules, which took longer than expected. Another respondent mentioned difficulties navigating the website using a screen reader.

Most Useful Features

A summary of the features that respondents found to be useful is presented in this sub-section.

a. **Personalised Learning Pathway:** This feature was highly appreciated by many participants (1, 6, 10, 14, 19, 23, 27).

b. **Interactive Modules and Quizzes:** Many users (3, 8, 9, 11, 18, 24, 30) found the interactive aspects and real-time quizzes to be very useful.

c. **Step-by-Step Guides:** Participants (4, 12, 20, 29) valued the detailed guides for their clarity and ease of use.

d. **Clear and Timely Feedback:** The clarity and timeliness of feedback were highlighted by several respondents (2, 15, 22).

e. Several respondents found the personalised learning pathway valuable because it can be adapted to their progress. Also, they highlighted that the clear and timely feedback on their interactions was useful.

Table 4.10 depicts the issues encountered by respondents and the features of the website which they found to be useful.

Table 4.10 Website's Issues and Useful Reported by Respondents

Participant	**Specific Issues Encountered**	**Most Useful Features**
1	Load times on educational modules were slow.	Personalised learning pathway.
2	Difficulty navigating with a screen reader.	Clear and timely feedback.
3	No comment.	Interactive modules.
4	Confusing navigation.	Step-by-step guides.
5	Broken links in some sections.	Real-time quizzes.
6	Nil	Personalized learning pathway.
7	Difficulty finding specific resources.	Clear module progression.
8	None.	Detailed explanations.
9	Long wait times for feedback.	Interactive modules.
10	Overwhelming information on some pages.	Personalized learning pathway.
11	Nil	Real-time quizzes.
12	Difficulty with mobile accessibility.	Step-by-step guides.
13	Slow video load times.	Interactive modules.

Table 4.10 continued

14	None.	Personalized learning pathway.
15	Broken images on some pages.	Clear and timely feedback.
16	Not easy to navigate on mobile devices.	Real-time quizzes.
17	Issues with logging in.	Detailed explanations.
18	Cannot view images on some pages.	Interactive modules.
19	Long load times for pages.	Personalized learning pathway.

20	None.	Step-by-step guides.
21	Confusing layout.	Real-time quizzes.
22	Missing images in some sections of the website.	Clear and timely feedback.
23	Difficulty with accessibility features.	Personalized learning pathway.
24	Pages taking long time to load.	Interactive modules.
25	Inconsistent design across pages.	Detailed explanations.
26	Accessibility issues.	Real-time quizzes.
27	Slow response time on interactive features.	Personalized learning pathway.
28	The design in different sections is not the same.	Clear module progression.
29	Difficulty using the site on a tablet.	Step-by-step guides.
30	Two of the pages was overloaded with too much information.	Interactive modules.

DISCUSSION AND CONCLUSSION

Introduction

This chapter discusses the findings of applying a design thinking approach to enhance an IoT learning website prototype. The study aimed to address common issues identified by learners through a human-centred problem-solving process. The insights were gathered through semi-structured interviews and analysed using thematic analysis. The evaluation of the prototype was conducted through an online survey, involving thirty respondents.

Student learning today is increasingly supported by a diverse array of e-learning environments, with multimedia courseware being among the most prevalent. These environments feature a variety of user interface designs. The primary function of any interactive courseware is to motivate learners, facilitate meaningful learning, and keep them engaged. Therefore, such online courses should be meticulously designed and thoughtfully evaluated to ensure that meaningful learning is achieved. This section discusses the design thinking stages applied to the website in this study. The five stages include empathise, define, ideate, prototype, and testing.

Discussion on Empathy and User Experience

The empathise stage revealed some significant issues affecting existing educational websites. For example, learners expressed difficulties in navigation, complex menu structures, and the absence of an efficient search function. These findings align with previous research suggesting that poor navigation and user interface design significantly impact user engagement and learning outcomes (Corrales-Estrada, 2020). Maintaining a uniform navigation system enables users to quickly browse websites without being confused or frustrated. Consistent

navigation facilitates users' seamless access to information and enables them to execute desired actions without difficulties. Poorly organised menus make it difficult for users to identify information, which ca result in a negative user experience. In educational websites, it is crucial for the menu to be well structured for effective user interaction and a more enjoyable user experience. Additionally, a well-structured menu enhances accessibility by providing clear navigation pathways for user (Moczarny et al., 2012). These features will enhance the overall user experience with online educational learning platforms. Importantly, absence of efficient search function on educational websites can affect its efficiency (Markey et al., 2019; Chevalier et al., 2015).

In summary, addressing issues identified during the empathize stage, particularly regarding navigation and user interface design, is crucial for improving the overall user experience on educational websites. Ensuring that websites have consistent structure with an and intuitive navigation systems can enhance user engagement and optimise learning outcomes in online educational environments. The next stage involved the identified themes and issues.

DISCUSSION ON IDENTIFIED THEMES AND ISSUES

The thematic analysis identified six major themes: Navigation and Layout, Design Elements, Complex Menus and Lack of Search Function, User Experience, Feedback, and Device Compatibility. Notably, the lack of immediate and detailed feedback was a recurrent issue, underscoring the importance of responsive and interactive elements in educational websites (Carlgren et al., 2016). Navigation and layout are essential to user experience. This is because a well-organized navigation and layout facilitate ease of use, enabling learners find information quickly and efficiently (Zhang et al., 2023; Wilson, 2009). In educational websites, poor navigation design can cause user frustration, decreased engagement, and deter the learning process. This is critical because learners are expected to frequently access content such as lectures, assignments, and forums.

Design elements, including visual aesthetics, typography, and color schemes, affects users' initial impressions and their overall experience (Bhandari et al., 2019). Too complex designs can distract learners, while minimalist yet informative designs can enhance their focus and comprehension. According to (Hassenzahl, 2018) that clear, uncluttered interfaces contribute to a positive user experience by improving content accessibility. Complex menus and the absence of an efficient search function are major obstacles to user navigation Moczarny et al., 2012). Also, users reported that device compatibility is a significant issue affecting their effective use of educational websites. Mobile technology is becoming prevalent today. The increasing use of mobile devices for online learning means that educational websites need to be compatible with such. Hence, device compatibility enhances accessibility, allowing users to engage with learning materials anytime and anywhere (Anshari et al., 2017; Mehdipour & Zerehkafi, 2013). It supports flexible learning environments. Next, students were asked to propose solutions to the identified issues in the previous stages.

Discussion on Proposed Solutions and Prototype Development

Addressing the identified issues in Section 4.3, several solutions were proposed and implemented in the prototype. These included streamlining the layout, simplifying menu structures, enhancing search functionality, and providing clear instructions and feedback mechanisms. The prototype also emphasized responsive design to ensure compatibility across different devices, addressing the issue of device compatibility reported by learners. The development phase of the prototype was guided by established usability principles, ensuring that the website was user-friendly and met the diverse needs of learners. Features such as progress tracking, interactive modules, and personalised learning pathways were incorporated to enhance user engagement and satisfaction.

Discussion on Findings from Evaluation and User Feedback

The evaluation phase involved thirty participants who assessed the prototype based on various usability principles. The feedback was mainly positive, with significant improvements noted in navigation, user control, and overall efficiency. However, some issues such as load times and mobile accessibility were highlighted,

indicating areas for further refinement. Each metric for evaluating the prototype is discussed in the following sections based on the results.

Understandability and Clarity

Regarding understandability and clarity, the evaluation indicates that most respondents found the navigation of the e-learning platform easy (34%). However, some users reported a satisfactory experience (10%), and a minority found it challenging (7%). Additionally, 52% of respondents noted that the website provided clear instructions, and 45% indicated that the website had organized content. The effectiveness of the website guide was recognised by 72% of respondents, and similarly, 72% found the modules to be well outlined. These findings highlight the importance of straightforward, intuitive navigation and well-structured content in enhancing user experience and learning outcomes. The data suggests that while the website performs well in clarity and understandability, attention should be given to improving instructions and content organization. Thus, improved, more interactive navigation and precise instruction can improve user satisfaction.

Accessibility

Accessibility is crucial for e-learning platforms, and in this section, 52% of participants reported that the website was fully accessible with their current devices and technologies. Additionally, 34% or participants rated the prototype as accessible. Regarding assistive technologies, 41% of respondents had no difficulties, while 34% experienced only minor difficulties. Specific accessibility features such as colour contrast were rated very favourably by 41% of participants, and 38% found them favourable. Furthermore, 69% respondents confirmed the presence of 'alt text' for images, and 38% found the website fully navigable via keyboard, with an additional 34% rating it as navigable. These statistics underscore the need for comprehensive accessibility features to accommodate all users. Hence, the website was deemed to be generally accessible, but specific assistive technology integration and keyboard navigation improvements could further enhance learners' experience.

Consistency

Consistency in design plays a significant role in user satisfaction. In this regard, 38% of respondents rated the website as very consistent, and 38% rated it as consistent. The navigation layouts were perceived as intuitive by 31% of respondents and intuitive by 34%. This consistency in design helps users predict the platform's behaviour, making the learning experience smoother and more effective. The results show that consistent design and navigation in educational websites are crucial for an enjoyable user experience. Maintaining and improving these aspects will ensure that users can predict and understand site behaviour better.

Feedback and Responsiveness

Effective feedback and responsiveness are essential for learner engagement. In this study, 45% of participants reported consistently receiving immediate and precise feedback, while 31% often received it. Regarding the clarity of confirmation 38% agreed. This immediate and clear feedback helps learners correct their mistakes promptly and enhances their learning experience. Hence, effective feedback mechanisms are essential for user satisfaction. Therefore, continuous improvement of user feedback and website responsiveness will make learners more confident interacting with the course website.

User Control and Freedom

User control and freedom are vital for an empowering learning environment. Additionally, 41% of respondents reported that they had complete control over of their actions while using the learning environment, and 38% felt they a good level control. Hence, most respondents felt they had high level of autonomy while using the learning website. For undo actions and customisation, 34% of participants found it very easy, and 38% found it moderately easy to use. Additionally, 41% rated the course section accessibility as very accessible, and 34% rated it as accessible. Thus, these aspects can contribute to a more personalised and flexible learning

experience. It will enable learners to navigate and utilise the learning platform according to their preferences. Ensuring ease of customisation and accessibility is essential for maintaining user engagement.

Error Prevention and Handling

Error prevention and handling are critical for maintaining a smooth user experience. In this evaluation, 38% of participants found error prevention measures very effective, and 34% found them helpful. The clarity of error messages was rated very clear by 34% of respondents and 41%. Helpful resources on the website were found to be very useful by 34% of respondents. Hence, effective error prevention and precise error-handling mechanisms can reduce user frustration and ensure a more reliable learning experience. However, continuous enhancement in these areas can ensure a smooth user experience.

Efficiency of Use

Efficiency is a critical factor in the usability of e-learning platforms. Overall efficiency was rated very efficient by 41% of users and efficient by 38%. Load times were rated very quick by 41% of respondents and quick by 38%. These findings suggest that the platform's performance and ease of use efficiency significantly enhance the user experience. Thus, educational websites are expected to be efficient based on how long it takes to load the pages and contents. Accordingly, it was observed that shortcuts can increase the productivity and satisfaction of learners.

Aesthetic and Minimalist Design

Aesthetic and minimalist design contributes to the visual appeal and focus of e-learning platforms. In this evaluation, 38% of respondents found the design very appealing, and 38% found it appealing. Regarding design focus, 38% of users felt it was very focused, and 38% found it moderately focused. A clean and visually appealing design helps to reduce distractions and improve learner engagement. Thus, aesthetic, appealing, and focused design can make the learning more enjoyable for users. It also ensures a visually pleasing and functional user interface. Hence, it can improve user engagement with the course website.

Recognition Rather Than Recall

Minimising memory load is crucial for user-friendly interface design. For memory load minimisation, 38% of participants felt the website performed very well, and 38% felt it performed well. Concerning information recall, 45% of users never had to remember information from one part of the dialogue to another, while 31% had to do so sometimes. These findings emphasise the importance of designing interfaces that reduce cognitive load and help users to focus on learning. Therefore, ensuring educational websites apply recognition rather than recall for leaner convenience is essential.

Flexibility and Adaptability

Flexibility and adaptability are essential for accommodating diverse learner needs. In this study, 41% of respondents found the website very flexible, and 34% found it flexible. For tailoring actions, 38% found it very easy, and 38% found it easy. Regarding personalised learning experiences, 41% of users felt the website provided these opportunities, and 34% reported that it was satisfactory. Flexible and adaptable designs can enable learners to customise their learning paths, enhancing their overall experience. Thus, maintaining this feature on educational websites allows diverse learners to enjoy using the sites.

Visibility of System Status

The visibility of the system's status ensures that users are always informed about the system's state. In this evaluation, 38% of respondents found feedback timeliness very timely, and 38% found it timely. Regarding status information, 41% of participants felt informed about what was happening while using the website, and 34% often felt informed. Keeping users informed helps to build trust and ensures a smooth learning process. Therefore, timely feedback and clear visibility of system status are crucial for user confidence and understanding of how the platform functions. It will ensure transparent user interactions.

Image Placement

Effective image placement enhances comprehension and engagement. Regarding the effectiveness of image placement, 38% of participants found it very effective, and 38% found it compelling. Concerning the placement of essential photos and content, 41% of users rated it excellent, and 34% rated it good. The strategic placement of images can aid in visual learning and keep users engaged. Hence, effective image placement can improve visual communication and support user comprehension and engagement.

Standards

Adherence to design standards ensures consistency and reliability. For design conventions, 38% of respondents felt the website followed them very well, and 38% felt it followed them well. Regarding interaction consistency, 38% found it very consistent, and 38% found it consistent. Following established standards helps in creating intuitive and reliable user interfaces. Hence, educational websites should adhere to design standards and use a consistent structure for a more enjoyable user experience. Maintaining these standards helps to support usability and user satisfaction.

In summary, this study successfully applied a design thinking approach to develop an enhanced IoT learning website prototype. The iterative process of empathising, defining, ideating, prototyping, and testing ensured that the final product was closely aligned with user needs and preferences. The integration of the ADDIE model provided a structured framework for instructional design, further enhancing the effectiveness of the learning platform.

The findings highlight the importance of user-centred design in developing educational technologies. In addressing common issues such as navigation difficulties, lack of feedback, and device compatibility, the study contributes to the growing body of knowledge on effective e-learning solutions. The positive user feedback validates the proposed design solutions and highlights the potential of the prototype to improve online learning experiences.

Recommendations

Based on the findings, several recommendations can be made for future development and research:

Enhance Load Times

a. **Optimisation of Content Delivery:** To reduce load times, it is crucial to optimise the website's content delivery. This can be achieved by compressing images and using efficient coding practices to minimise the use of heavy graphics and scripts. Implementing content delivery networks (CDNs) can also distribute content more efficiently, ensuring faster load times for users globally (Vakali & Pallis, 2003). Hence, users will have an enhanced learning experience when using online educational platforms.

b. **Efficient Coding Practices:** Streamlining the codebase by removing unnecessary elements and optimising scripts can significantly improve website performance. Techniques such as asynchronous loading and lazy loading can ensure that only essential content is loaded initially, with additional elements loaded as needed (Liang et al., 2024; Mjelde & Opdahl, 2017).

c. **Regular Performance Audits:** Conducting regular performance audits can help identify bottlenecks and areas for improvement. Tools like Google PageSpeed Insights and GTmetrix can provide actionable insights into the website's performance and suggest optimisations (Roumeliotis et al., 2022).

Mobile Accessibility

a. **Responsive Design:** Ensuring that the website is fully responsive and adapts seamlessly to different screen sizes and orientations is essential. This involves using flexible grids and layouts, scalable images, and media queries to create a consistent user experience across devices (Mohamed et al., 2014). This will improve the interactivity of the educational website.

b. **Mobile-First Approach:** Adopting a mobile-first design approach can prioritise mobile users' needs (Roth et al., 2024). It ensures that the most critical features and content are accessible on smaller screens. This approach often results in a cleaner, more efficient design that benefits all users.

c. **Cross-Platform Testing:** Comprehensive testing across various mobile devices and operating systems is crucial to identify and resolve compatibility issues (Choudhary, 2014). Automated testing tools and manual testing should be used to ensure the platform functions correctly on all devices. Online learning platforms must ensure their interfaces are compatible with various devices, including smartphones and tablets, to provide a seamless and efficient learning experience.

Feedback Mechanisms

a. **Instant and Detailed Feedback:** Developing systems that provide instant and detailed feedback on quizzes and assignments can enhance the learning experience (Wong et al., 2017; Sabag & Kosolapov, 2012). Automated feedback can be programmed to address common errors and provide corrective guidance, helping learners understand their mistakes and learn more effectively. Thus, users will have greater confidence in using the website.

b. **Peer Review Systems:** Implementing peer review systems can enrich the feedback process (Gikandi & Morrow, 2016). These systems allow learners to review each other's work, providing diverse perspectives and fostering a collaborative learning environment. Structured rubrics and guidelines can ensure that peer feedback is constructive and valuable.

c. **Personalised Feedback:** Personalising feedback based on individual learner performance can make it more relevant and impactful (Li & Wong, 2023; Major et al., 2021). Using data analytics to track learner progress and customize feedback can significantly enhance motivation and engagement.

User Support

a. **Real-Time Assistance:** Strengthening the support system with real-time assistance options such as live chat can greatly enhance the user experience (Chen et al., 2011). Real-time support ensures that users receive immediate help, reducing frustration and improving satisfaction. When users receive real-time support, they are more likely to continue engaging with the learning platform.

b. **Comprehensive Knowledge Bases:** Developing a comprehensive knowledge base with detailed guides, FAQs, and video tutorials can empower users to resolve issues independently (Kaklauskas & Kaklauskas, 2015). An easily navigable support section can significantly reduce the need for direct assistance. Hence this can increase the learners' experience when using the website.

c. **Responsive Support Systems:** Support systems that are responsive and capable of handling user queries efficiently are essential (Chen et al., 2011; Oduoza, 2010). Implementing ticketing systems and feedback loops can help track and resolve issues promptly.

Customisation Features

a. **Personalised Learning Paths:** Expanding customisation options to allow learners to tailor their learning paths can enhance engagement and motivation (Petersen & Gundersen, 2019). Personalised learning paths can adapt to individual needs, preferences, and progress, providing a more relevant and effective learning experience.

b. **Progress Tracking Tools:** Implementing robust progress tracking tools that visually display learners' achievements and milestones can help learners stay motivated (Petersen & Gundersen, 2019). Features such as progress bars, badges, and certificates can provide tangible recognition of their efforts.

c. **Adaptive Learning Technologies:** Adaptive learning technologies that adjust content and assessments based on learner performance can provide a more personalised and practical learning experience (Munzo et

al., 2022). Adaptive learning enables educators to plan an effective personalised teaching experience for learners and customise resources and activities based on individual learning needs. These technologies can identify areas where learners need additional support and provide targeted resources and activities.

Iterative Testing and Refinement

a. **Continuous User Feedback:** Regularly collecting and analyzing user feedback is essential for continuous improvement (Firmenich et al., 2019). User feedback can provide valuable insights into the effectiveness of the platform and highlight areas for enhancement. Hence, this will enhance users' online learning experience.

b. **Split Testing:** Employing Split or A/B testing methods can help determine the most effective design elements and features to implement on the website (Firmenich et al., 2019). A comparison of different versions of the website allows developers to identify which changes positively impact user experience and learning outcomes. For example, split testing can reveal whether users prefer a particular layout, call-to-action button color, or content arrangement, leading to higher engagement and satisfaction. This data-driven approach ensures that design decisions are based on user behavior rather than assumptions. This leads to a more user-centric and effective website that enhances user experience. Ultimately, split testing helps create websites that match with users' preferences making their interactions with the educational website more enjoyable and productive.

c. **Agile Development Practices:** Adopting agile development practices can ensure that the platform evolves based on user needs and technological advancements (Cao et al., 2009). Iterative development cycles, with regular updates and improvements, can keep the platform responsive and relevant.

In addressing these recommendations, future developments can significantly enhance the usability, accessibility, and effectiveness of the IoT learning website. Ensuring that the platform evolves based on user needs and technological advancements will create a more engaging and effective learning environment.

Limitations of the Study

Despite its contributions, this study has several limitations. Some limitations are highlighted in this section.

a. **Sample Size:** The study involved a relatively small sample size, which may limit the generalizability of the findings. Future research should include a larger and more diverse sample to validate the results.

b. **Short-Term Evaluation:** The evaluation of the prototype was conducted over a short period. Longitudinal studies are needed to assess the long-term impact of the design improvements on learning outcomes and user satisfaction.

c. **Limited Demographic Diversity:** The study participants were predominantly from specific educational backgrounds and regions. Including a more diverse demographic could provide a broader understanding of user needs and preferences.

d. **Scope of Features:** The prototype focused on specific features and usability principles. Future studies could explore additional functionalities and their impact on user experience.

e. **Technological Constraints:** The study was conducted within certain technological constraints, which may have influenced the design and functionality of the prototype. Future research should explore the use of advanced technologies to enhance the learning platform.

Future Study Considerations

To address the limitations identified in this study, several considerations should be considered in future research:

Expand Sample Size and Diversity

a. **Larger Sample Size:** Future studies should aim to include a larger sample size to enhance the generalizability of the findings. This will provide more robust data and ensure that the conclusions drawn are applicable to a broader population.

b. **Diverse Demographic Representation:** Incorporate participants from various educational backgrounds, regions, and age groups. This diversity will help in understanding the different needs and preferences of users across different demographics, leading to a more inclusive and universally effective design.

Longitudinal Studies

a. **Extended Evaluation Period:** Conduct longitudinal studies to assess the long-term impact of the design improvements on learning outcomes and user satisfaction. This approach will provide insights into how users interact with the platform over time and whether initial positive feedback translates into sustained use and improved educational performance.

b. **Behavioural and Performance Metrics:** Track behavioural data and performance metrics over an extended period to evaluate how the design affects learning efficiency, retention, and engagement. This data will help in understanding the effectiveness of the design in real-world educational settings.

Exploration of Additional Features

a. **Advanced Functionalities:** Investigate the impact of incorporating advanced functionalities such as artificial intelligence-driven personalized learning paths, gamification elements, and virtual/augmented reality components. These features could further enhance user engagement and learning outcomes.

b. **Interactivity and Collaboration Tools:** Examine the effectiveness of enhanced interactivity and collaboration tools, such as real-time group work, discussion forums, and peer feedback systems. Understanding how these tools affect learning and user satisfaction can lead to more effective educational platforms.

Technological Enhancements

a. **Utilisation of Emerging Technologies:** Explore the use of emerging technologies like machine learning, blockchain for credentialing, and adaptive learning algorithms. These technologies can provide more personalized and secure learning experiences.

b. **Performance Optimization:** Focus on optimizing the website's performance, including load times, scalability, and cross-platform compatibility. Future studies should assess how these technical improvements impact user experience and learning efficiency.

Cross-Cultural Studies

a. **Cultural Adaptability:** Conduct cross-cultural studies to understand how cultural differences influence user interactions with the learning platform. This will help in creating culturally adaptable and sensitive designs that cater to a global audience.

b. **Localisation and Internationalization:** Investigate the effectiveness of localised content and internationalization features. This includes translating content, adapting cultural references, and ensuring that the platform meets regional educational standards and preferences.

Detailed Usability and Accessibility Testing

a. **Inclusive Design Testing:** Perform comprehensive usability and accessibility testing with participants who have diverse abilities and disabilities. This will ensure that the platform is accessible to all users and complies with universal design principles.

b. **User-Centred Iterative Design:** Employ a user-centred iterative design process involving continuous feedback loops with end-users. This approach will help in identifying and addressing usability issues promptly, leading to a more refined and user-friendly platform.

Comparative Studies

a. **Benchmarking Against Other Platforms:** Conduct comparative studies to benchmark the IoT learning website against other similar platforms. This will provide insights into relative strengths and weaknesses, helping to identify best practices and areas for improvement.

b. **Impact Analysis of Different Design Approaches:** Compare the effectiveness of different design approaches, such as design thinking vs. traditional instructional design in enhancing user experience and learning outcomes. This can help in determining the most effective design methodologies for educational technologies.

Integration with Educational Ecosystems

a. **Interoperability with Learning Management Systems:** Study the integration of the IoT learning website with existing Learning Management Systems (LMS) and other educational tools. This will ensure seamless user experiences and enhance the platform's utility within broader educational ecosystems.

b. **Data Privacy and Security:** Investigate the implications of data privacy and security measures on user trust and engagement. Ensuring robust data protection protocols will be critical for the platform's acceptance and success.

Summary

The chapter presents the findings of a study aimed at enhancing an IoT learning website prototype using a design thinking approach. The research addressed common issues identified by learners through semi-structured interviews and thematic analysis. Key issues included navigation difficulties, complex menu structures, and inefficient search functions, significantly impacting user engagement and learning outcomes.

The study followed the five stages of design thinking: empathise, define, ideate, prototype, and test. Learners' difficulties were identified in the empathize stage, emphasizing the need for consistent navigation and efficient search functions. Thematic analysis revealed six major themes: navigation and layout, design elements, complex menus, user experience, feedback, and device compatibility. Solutions included streamlining the layout, simplifying menus, enhancing search functionality, and ensuring device compatibility.

Evaluation of the prototype with thirty respondents showed significant improvements in navigation, user control, and efficiency. However, issues like load times and mobile accessibility were reported. Metrics such as understandability, accessibility, consistency, feedback, user control, error prevention, efficiency, aesthetic design, memory load minimisation, flexibility, and system status visibility were evaluated, highlighting areas for further refinement.

Recommendations for future development include optimizing load times, improving mobile accessibility, enhancing feedback mechanisms, providing real-time user support, and implementing customization features. The study also suggests continuous user feedback, split testing, and adopting agile development practices to ensure the platform evolves based on user needs and technological advancements.

In summary, the study underscores the importance of user-centred design in developing educational technologies, contributing to effective e-learning solutions by addressing navigation difficulties, lack of feedback, and device compatibility. The positive user feedback validates the proposed design solutions, indicating the potential for improved online learning experiences. In conclusion, this study demonstrates the effectiveness of a design thinking approach in developing user-centred educational technologies. The findings and recommendations provide valuable insights for practitioners and researchers aiming to enhance online learning experiences. Furthermore, this study contribute to this growing area of research by exploring the

application of design principle approach and ADDIE model to enhance an educational website in a single study. Continued research and iterative development are essential to ensure that educational websites meet the evolving needs of learners in an increasingly digital world. Researchers can build upon the findings of this study to develop more effective, inclusive, and user-friendly educational technologies that cater to the diverse needs of learners in an increasingly digital world.

DECLARATION

I declare that this project report entitled *"design a website for learning iot programming by integrating design thinking elements"* is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	.....
Name	:	ALHARBI FAISAL BADER M
Date	:	3 JULY 2024

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BAHAGIAN A - Pengesahan Kerjasama*

Adalah disahkan bahawa projek penyelidikan tesis ini telah dilaksanakan melalui

kerjasama antara _____dengan _____

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Tesis ini telah diperiksa dan diakui oleh:

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Nama Penyelia Lain (jika ada)	**:**	

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Tandatangan : Tarikh : 22 JULAI 2020

Nama :

APPENDIX A

Online Survey: Evaluating the Usability and Effectiveness of Learning Internet of Things Website

Section 1: Understandability and Clarity
1. Navigation and Instructions

How straightforward did you find the navigation of our website? (Likert scale: 1 - Very Difficult, 5 - Very Easy)	**5**	**4**	**3**	**2**	**1**
Were the instructions on the website clear and easy to follow? (Likert scale: 1 - Not Clear, 5 - Very Clear)	**5**	**4**	**3**	**2**	**1**
How logically organized was the content on the website? (Likert scale: 1 - Very Disorganized, 5 - Very Organised)	**5**	**4**	**3**	**2**	**1**
2. Educational Pathways					
Did the educational pathways guide you effectively through your learning journey? (Likert scale: 1 - Not at All, 5 - Very Effectively)	**5**	**4**	**3**	**2**	**1**
How would you rate the delineation of different educational modules? (Likert scale: 1 - Poor, 5 - Excellent)	**5**	**4**	**3**	**2**	**1**
Section 2: Accessibility					
3. General Accessibility					
Was the website accessible to you with your current devices and technologies? (Likert scale: 1 - Not Accessible, 5 - Fully Accessible)	**5**	**4**	**3**	**2**	**1**
Did you encounter any difficulties using assistive technologies (e.g., screen readers)? (Likert scale: 1 - Major Difficulties, 5 - No Difficulties)	**5**	**4**	**3**	**2**	**1**
4. Specific Accessibility Features					
How appropriate were the colour contrasts on the website? (Likert scale: 1 - Very Inappropriate, 5 - Very Appropriate)	**5**	**4**	**3**	**2**	**1**
Was alt text provided for images throughout the site? (Yes/No/I Did Not Notice)	**5**	**4**	**3**	**2**	**1**
How navigable was the website via keyboard? (Likert scale: 1 - Not Navigable, 5 - Fully Navigable)	**5**	**4**	**3**	**2**	**1**
Section 3: Consistency					
5. Design Elements					
How consistent were the design elements (colours, font styles, button shapes) across the website? (Likert scale: 1 - Very Inconsistent, 5 - Very Consistent)	**5**	**4**	**3**	**2**	**1**

Did you find the navigation layouts to be intuitive and consistent? (Likert scale: 1 - Not Intuitive, 5 - Very Intuitive)	**5**	**4**	**3**	**2**	**1**
Section 4: Feedback and Responsiveness					
6. Interaction Feedback					
Did you receive immediate and clear feedback on your interactions with the website? (Likert scale: 1 - Never, 5 - Always)	**5**	**4**	**3**	**2**	**1**
When you completed a module or submitted an assignment, was the confirmation clear and timely? (Likert scale: 1 - Not Clear, 5 - Very Clear)	**5**	**4**	**3**	**2**	**1**
Section 5: User Control and Freedom					
7. Control over Learning Environment					
How much control did you feel you had over your learning environment on the website? (Likert scale: 1 - No Control, 5 - Full Control)	**5**	**4**	**3**	**2**	**1**
Were you able to easily undo actions and customize your learning pathway? (Likert scale: 1 - Very Difficult, 5 - Very Easy)	**5**	**4**	**3**	**2**	**1**
How accessible were various course sections at your convenience? (Likert scale: 1 - Not Accessible, 5 - Very Accessible)	**5**	**4**	**3**	**2**	**1**
Section 6: Error Prevention and Handling					
8. Error Management					
How effective was the website in preventing user errors? (Likert scale: 1 - Not Effective, 5 - Very Effective)	**5**	**4**	**3**	**2**	**1**
Were error messages clear and helpful? (Likert scale: 1 - Not Clear, 5 - Very Clear)	**5**	**4**	**3**	**2**	**1**
Did the website provide helpful resources for common problems? (Likert scale: 1 - Not Helpful, 5 - Very Helpful)	**5**	**4**	**3**	**2**	**1**
Section 7: Efficiency of Use					
9. User Experience					
How would you rate the overall efficiency of your user experience on the website? (Likert scale: 1 - Very Inefficient, 5 - Very Efficient)	**5**	**4**	**3**	**2**	**1**
Were load times minimal and acceptable? (Likert scale: 1 - Very Long, 5 - Very Short)	**5**	**4**	**3**	**2**	**1**
Did the website offer shortcuts for experienced users to navigate quickly? (Yes/No-I	**5**	**4**	**3**	**2**	**1**

Did Not Notice)					
Section 8: Aesthetic and Minimalist Design					
10. Visual Design					
How appealing was the visual design of the website? (Likert scale: 1 - Not Appealing, 5 - Very Appealing)	**5**	**4**	**3**	**2**	**1**
Did the design focus on essential information without being cluttered? (Likert scale: 1 - Very Cluttered, 5 - Very Focused)	**5**	**4**	**3**	**2**	**1**
Section 9: Recognition Rather Than Recall					
11. Memory Load					
How well did the website minimize your memory load by making objects, options, and directions visible? (Likert scale: 1 - Not at All, 5 - Very Well)	**5**	**4**	**3**	**2**	**1**
Did you have to remember information from one part of the dialogue to another? (Likert scale: 1 - Very Often, 5 - Never)	**5**	**4**	**3**	**2**	**1**
Section 10: Flexibility and Adaptability					
12. Catering to Users					
How flexible was the website in catering to both new and experienced users? (Likert scale: 1 - Not Flexible, 5 - Very Flexible)	**5**	**4**	**3**	**2**	**1**
Were you able to tailor frequent actions to your needs? (Likert scale: 1 - Not at All, 5 - Very Easily)	**5**	**4**	**3**	**2**	**1**
Did the website provide opportunities for personalized learning experiences? (Likert scale: 1 - Not at All, 5 - Very Much)	**5**	**4**	**3**	**2**	**1**
Section 11: Visibility of System Status					
13. System Feedback					
How timely was the feedback provided by the website for your actions? (Likert scale: 1 - Very Delayed, 5 - Very Timely)	**5**	**4**	**3**	**2**	**1**
Were you informed about what was happening while using the website? (Likert scale: 1 - Never, 5 - Always)	**5**	**4**	**3**	**2**	**1**
Section 12: Image Placement					
14. Image Use and Placement					
How effectively were images placed next to the text they support? (Likert scale: 1 - Not Effective, 5 - Very Effective)	**5**	**4**	**3**	**2**	**1**

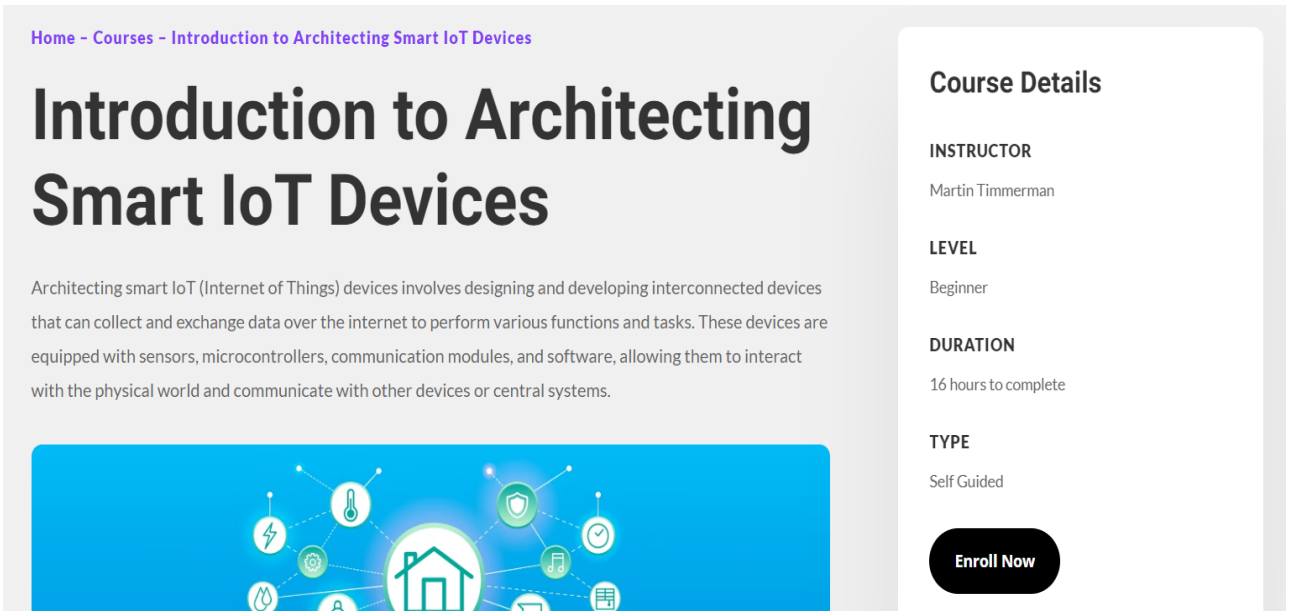
Were the most important photos and content placed at the top of the page? (Likert scale: 1 - Not at All, 5 - Very Well)	**5**	**4**	**3**	**2**	**1**
Section 13: Standards					
15. Design Conventions					
How well did the design follow well-established conventions to make the page familiar and easy to use? (Likert scale: 1 - Not at All, 5 - Very Well)	**5**	**4**	**3**	**2**	**1**
Was your interaction with the web page consistent with what you expect from other websites? (Likert scale: 1 - Not Consistent, 5 - Very Consistent)	**5**	**4**	**3**	**2**	**1**
Open-Ended Questions					
16. Overall Experience					
Please describe any specific issues you encountered while using the website.					
What features did you find most useful on the website?					
Do you have any suggestions for improving the usability and effectiveness of the website?					

Features of the website: https://designprinciples123.000webhostapp.com

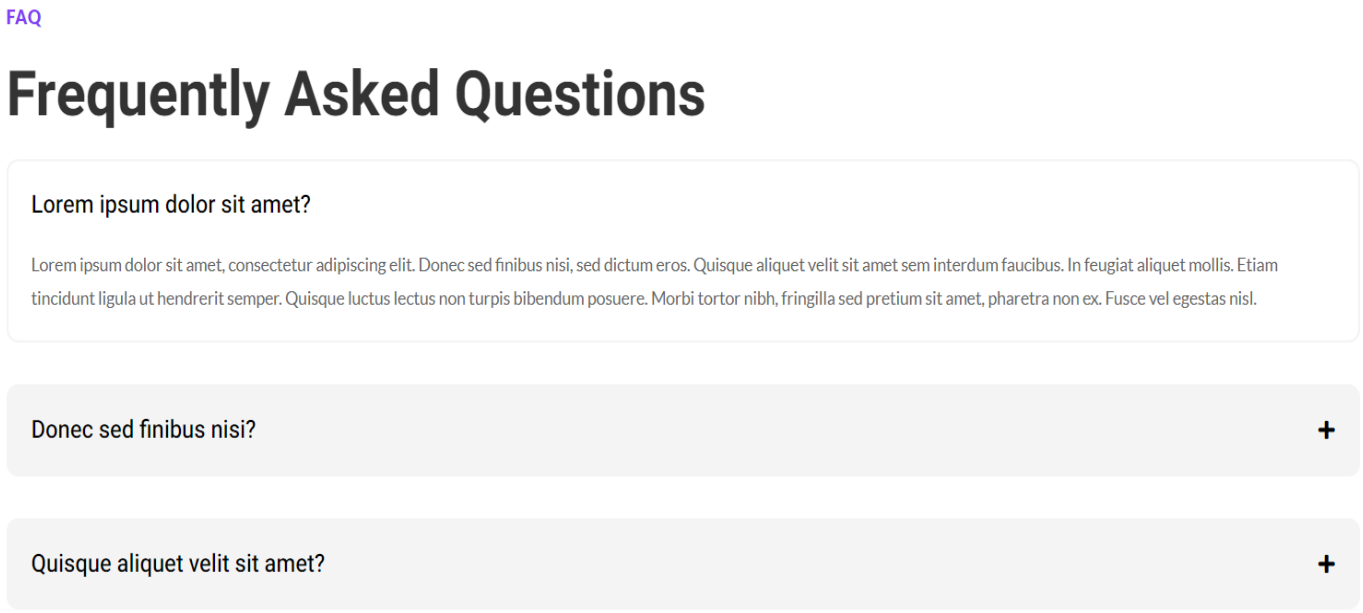
1. Understandability and Clarity

- **Clear Navigation:** A top navigation bar with clear labels for each main section (e.g., "Home," "Courses," "Contact").

- **Logical Content Organization:** Arranging course content chronologically or thematically, with headings and subheadings for easy scanning.

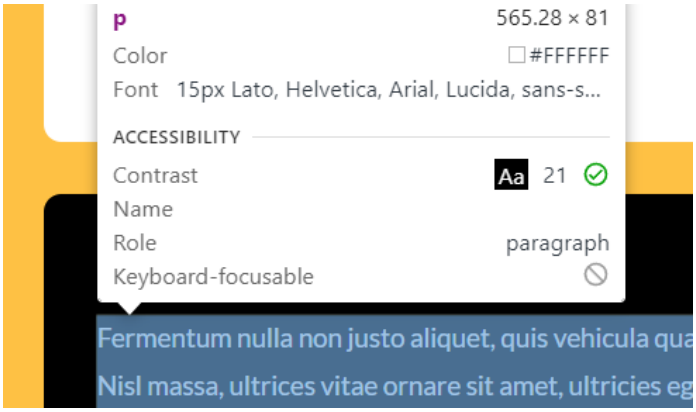


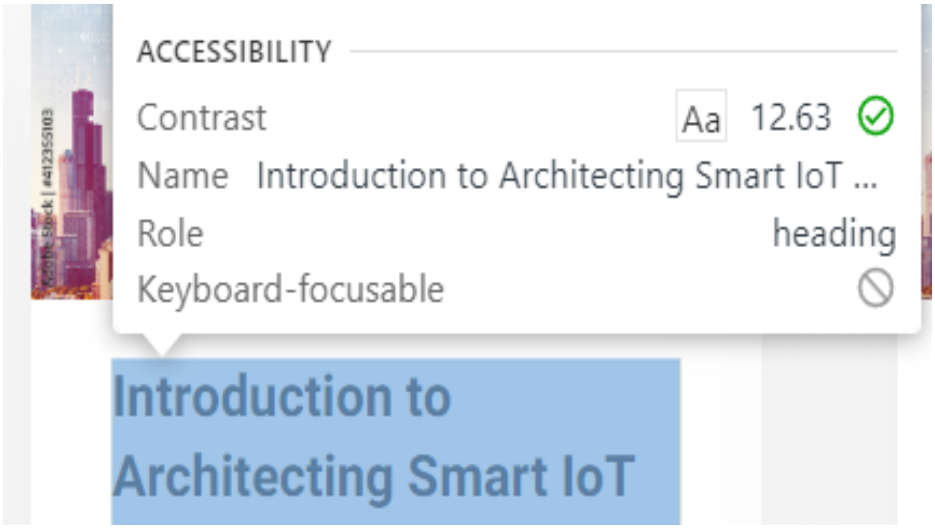
- **Interactive FAQs:** An FAQ section with expandable sections and clear answers to commonly asked questions.



Accessibility

High Contrast Text: Black text on a white background ensures readability for users with visual impairments.

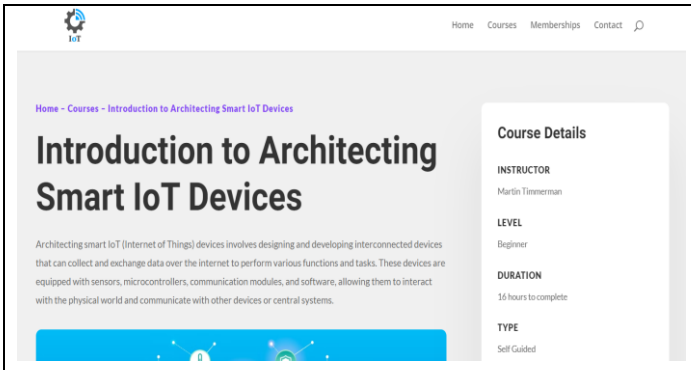




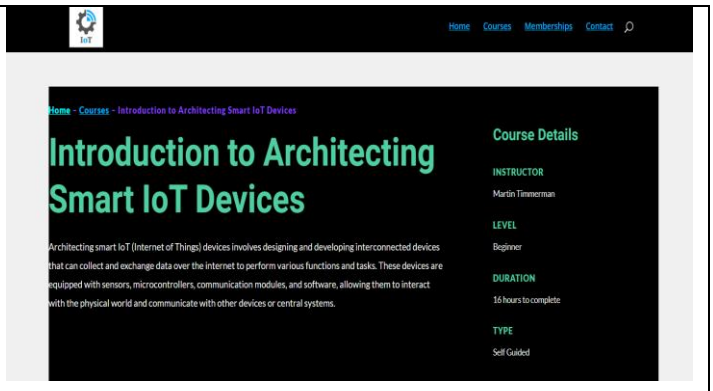
Alt Text for Images: Descriptive alternative text for images that conveys the image's content to screen readers for visually impaired users.

Accessibility Toolbar:

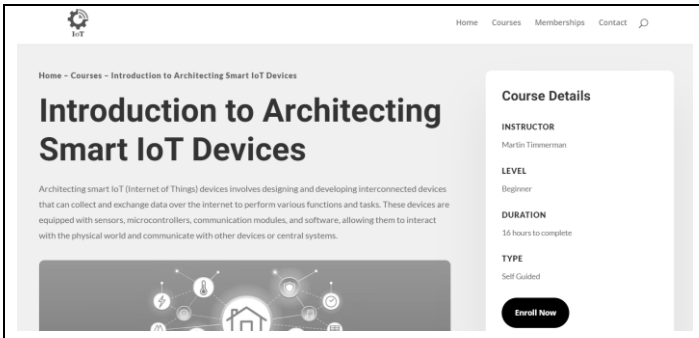
A customizable toolbar offering options to adjust color contrast, enable grayscale mode, and increase font size for improved readability.



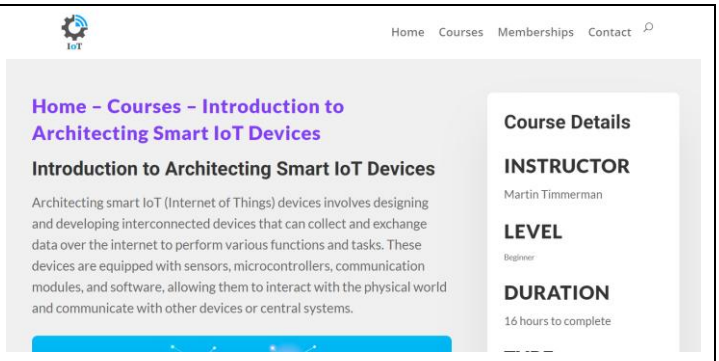
Original



Contrast Mode



Grayscale Mode



Font Size

Consistency

Color Palette: Using a consistent color scheme throughout the website, including primary and secondary colors, for a cohesive brand identity.

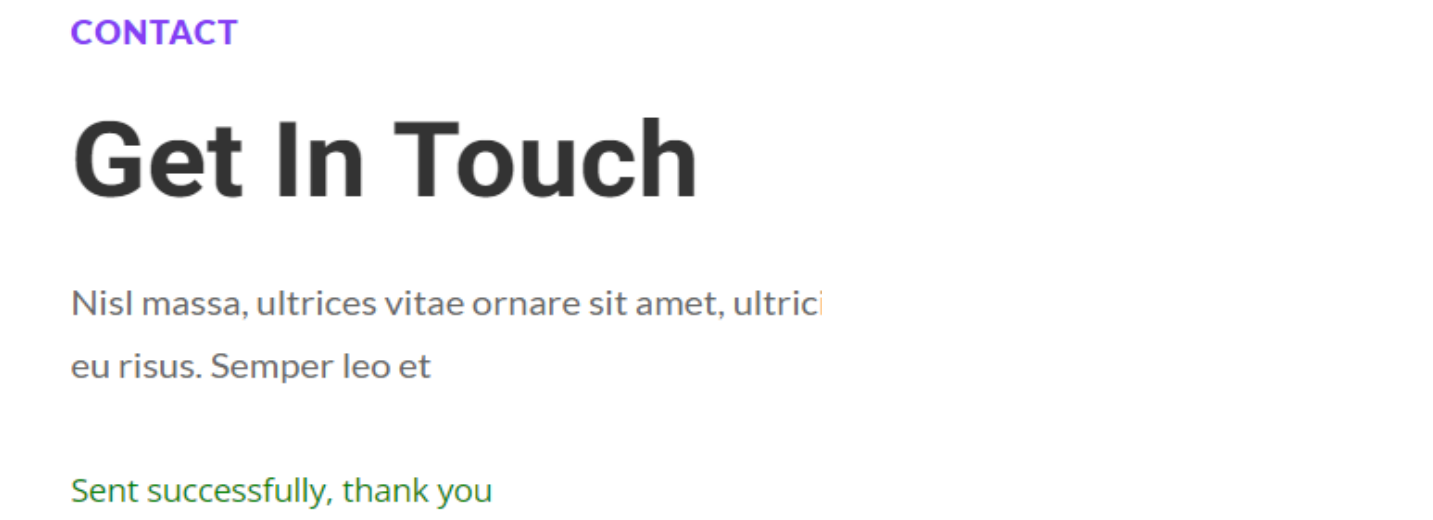
Font Styles: Maintaining a consistent font family and size for headings, body text, and buttons to create a unified visual experience.

Button Styles: Using the same style (e.g., rounded corners, blue background) for all call-to-action buttons to ensure users recognize them easily.

Feedback and Responsiveness

Progress Bars: Progress bars for lengthy video lectures indicating how much time is remaining.

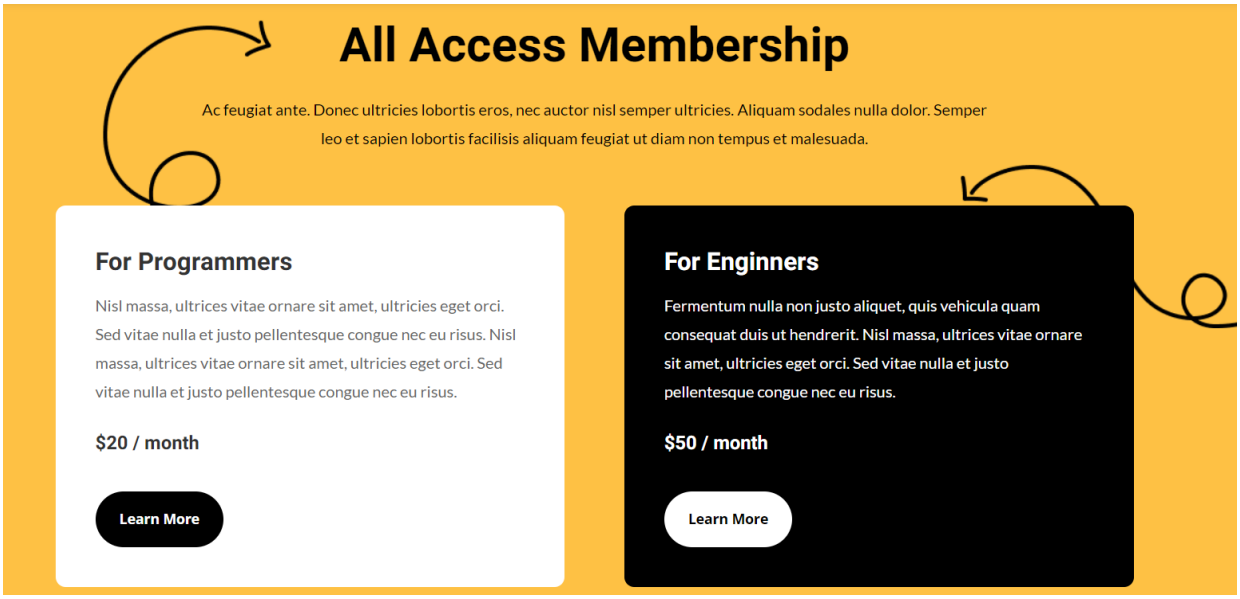
Confirmation Messages: A message confirming successful course enrollment or form pr assignemtn submission.



Interactive Quizzes: Instant feedback on quiz answers, allowing users to learn from mistakes immediately.

User Control and Freedom

Multiple Learning Paths: Offering curated learning paths but also allowing users to choose for a programmers courses or for an enginners experience.

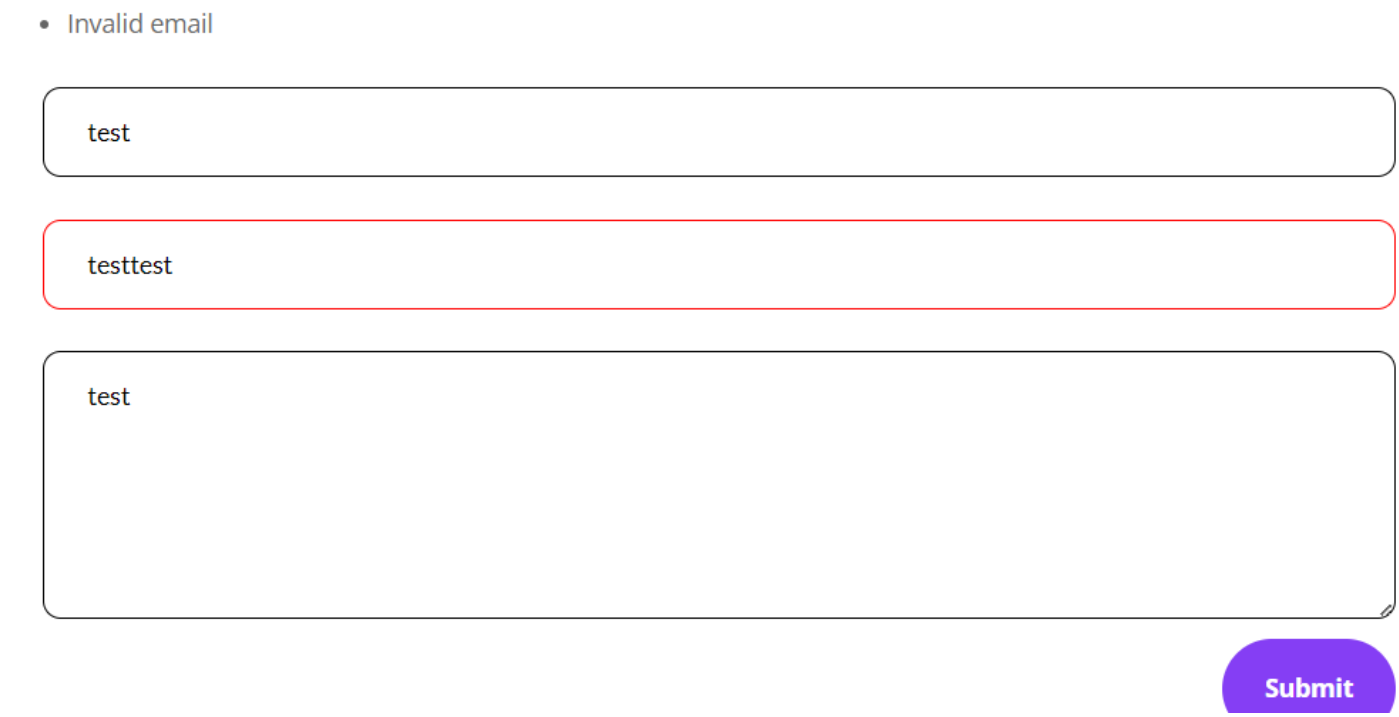


Downloadable Materials: Providing downloadable PDFs of lecture notes or presentations for offline access.

Bookmarking Functionality: A bookmarking feature that allows users to save their progress and easily return to unfinished sections.

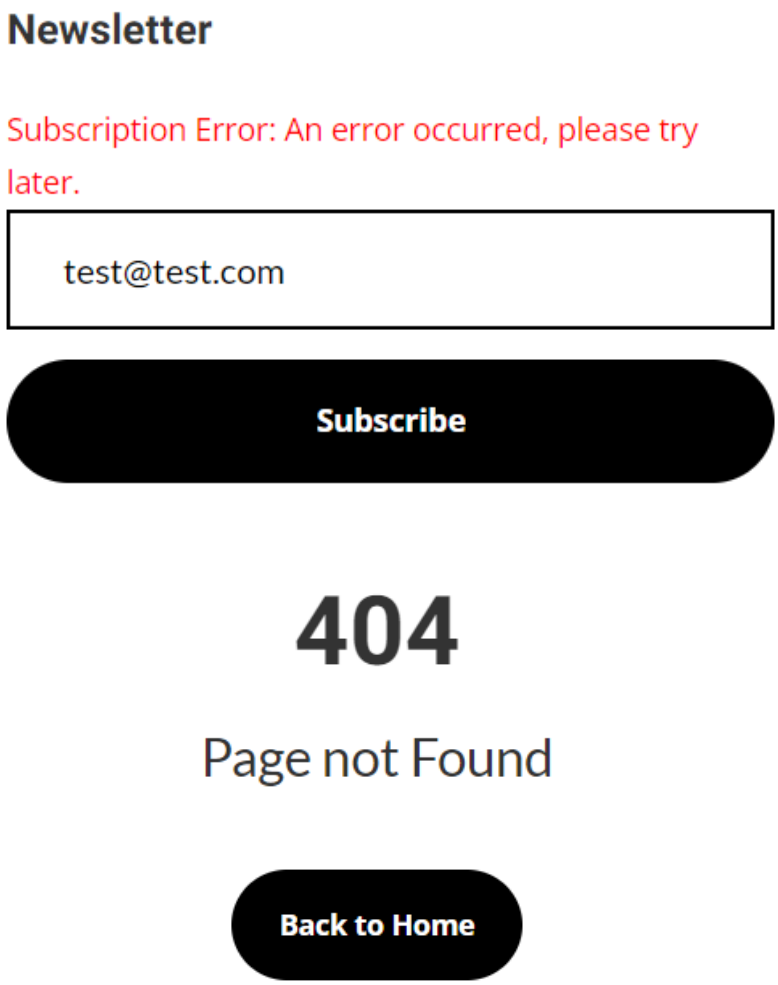
Error Prevention and Handling

Form Validation: Real-time validation on forms, highlighting missing information or incorrect formats before submission.



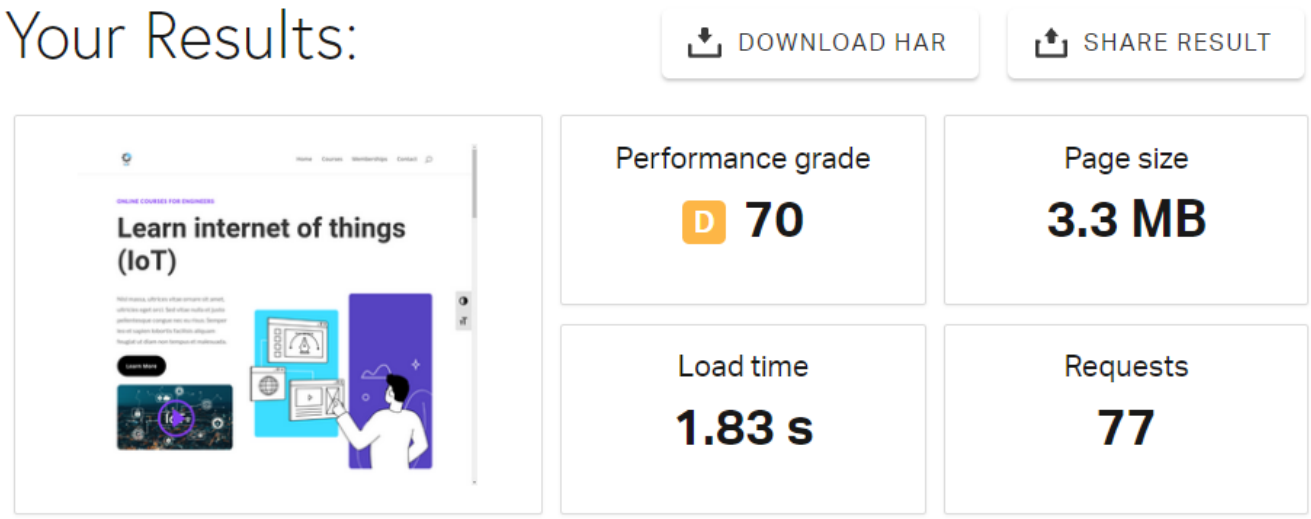
Confirmation Before Deletion: A confirmation pop-up before users delete important course materials, preventing accidental loss.

Detailed Error Messages: Informative error messages that explain the issue and offer solutions, instead of generic error codes.



Efficiency of Use

Fast Loading Times: Optimizing images and code for fast loading speeds across various devices.



Search Functionality: A robust search bar that allows users to quickly find specific course content or topics.

Keyboard Shortcuts: Providing keyboard shortcuts for common actions like navigating between modules or taking notes.

Aesthetic and Minimalist Design

Whitespace Utilization: Strategic use of whitespace between elements to improve visual clarity and avoid overwhelming users.

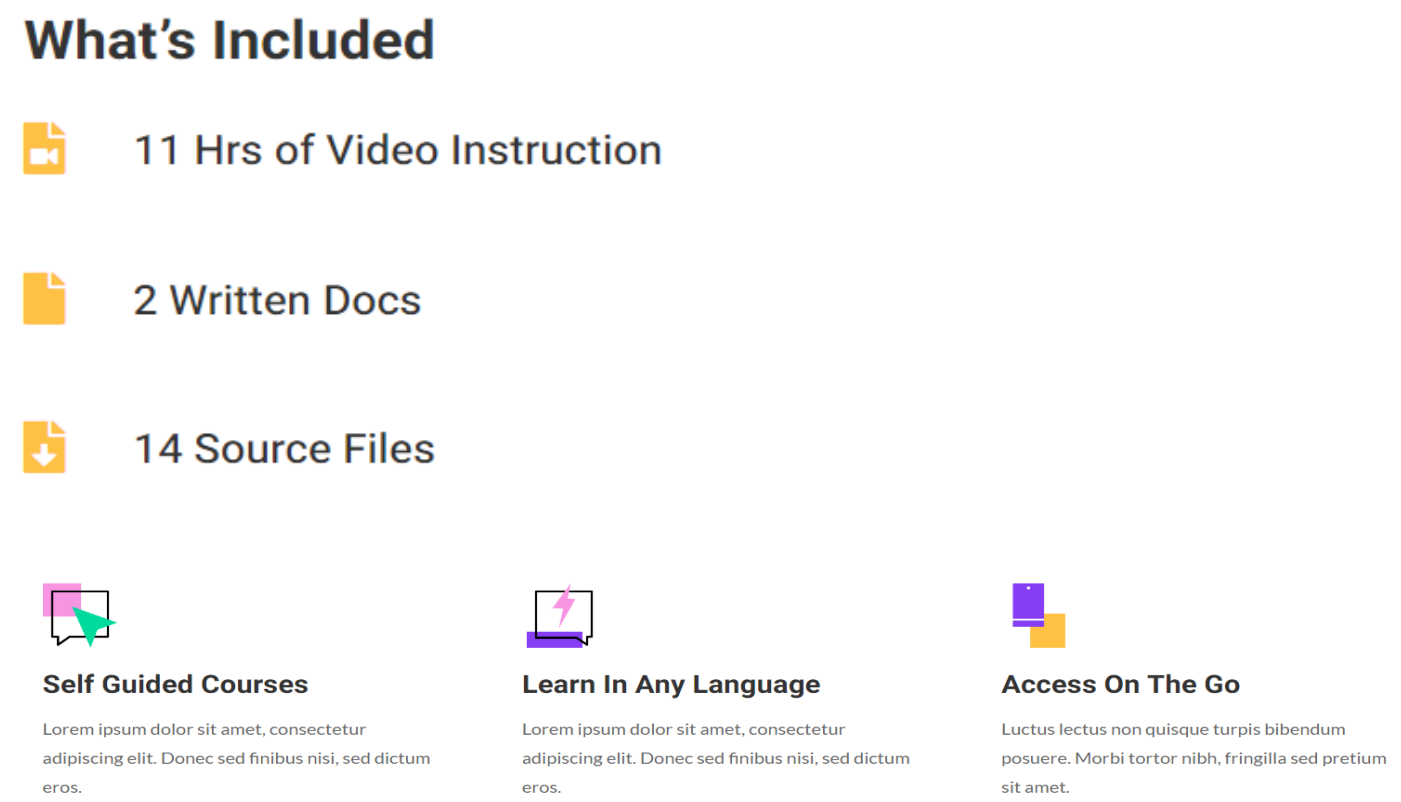
High-Quality Images: Using professional-looking images and icons that complement the website's overall design aesthetic.

Limited Animations: Sparing use of animations that don't directly contribute to the user experience or distract from the learning content.

Recognition Rather Than Recall

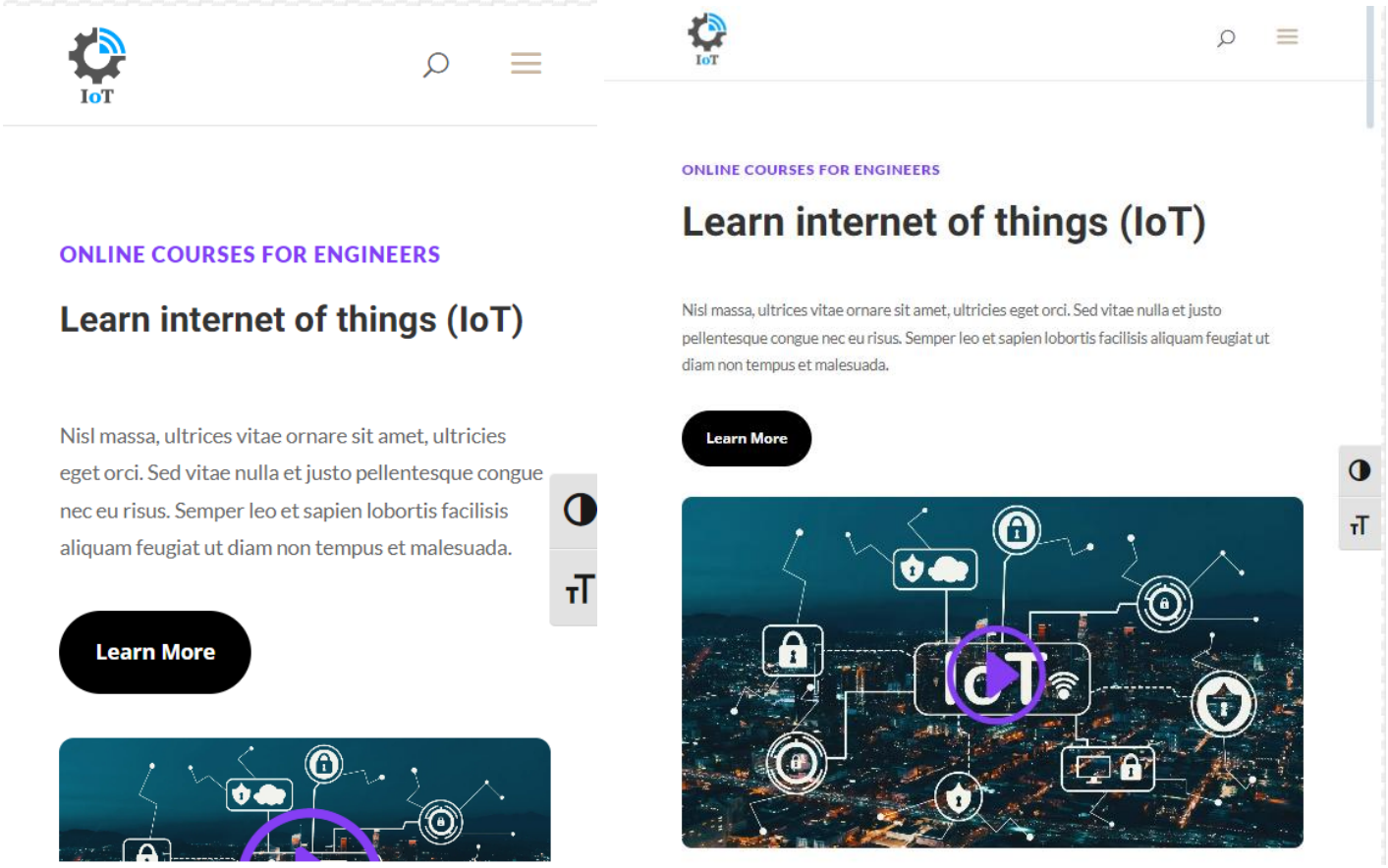
Breadcrumbs: A breadcrumb navigation bar at the top of the page that shows users their current location within the course structure.

Iconography: Using clear and consistent icons for common functionalities, such as play buttons for videos and download icons for downloadable materials.



Flexibility and Adaptability

Responsive Design: A website that automatically adjusts its layout for optimal viewing on any device (desktop, tablet, mobile).



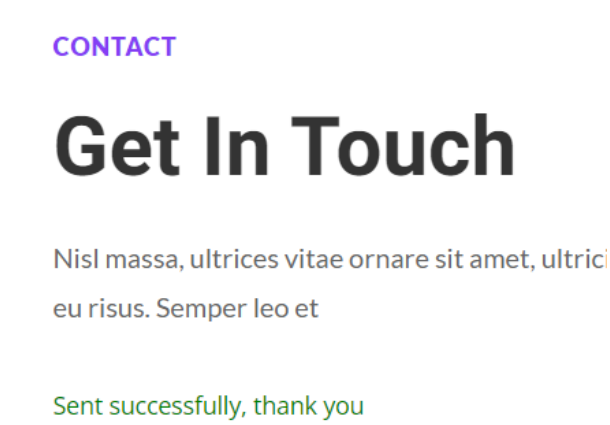
Multiple Difficulty Levels: Offering courses at different difficulty levels to cater to users with varying levels of prior knowledge.

Personalized Recommendations: Recommending additional courses based on users' previous learning activity and interests.

Visibility of System Status

Loading Spinners: While a course video loads, displaying a loading spinner to inform users that the system is working.

Submission Confirmation: After submitting a form, displaying a message indicating whether the submission was successful or not.



Maintenance Mode Page: A Maintenance Mode Page is a temporary placeholder displayed to visitors when your website is undergoing maintenance, updates, or experiencing technical difficulties.

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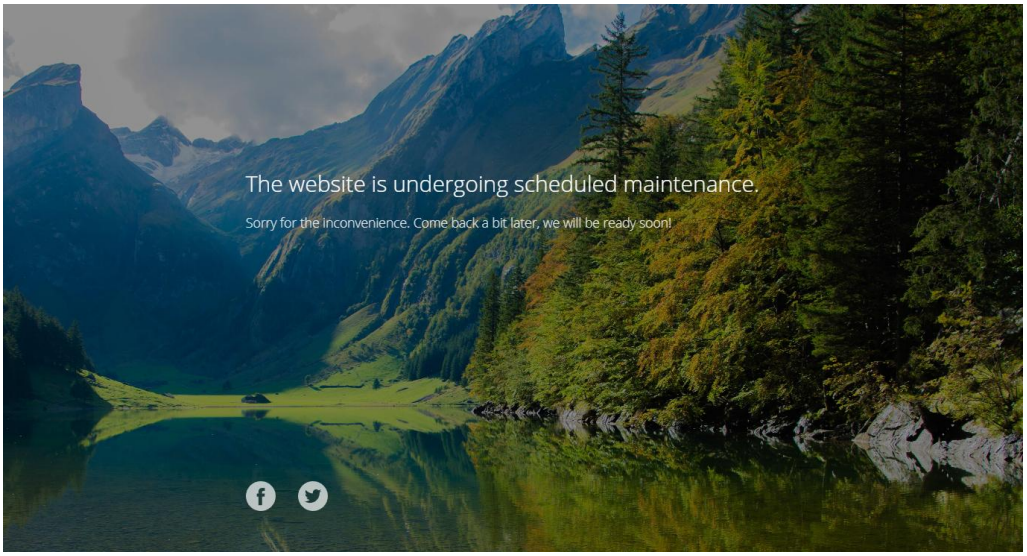
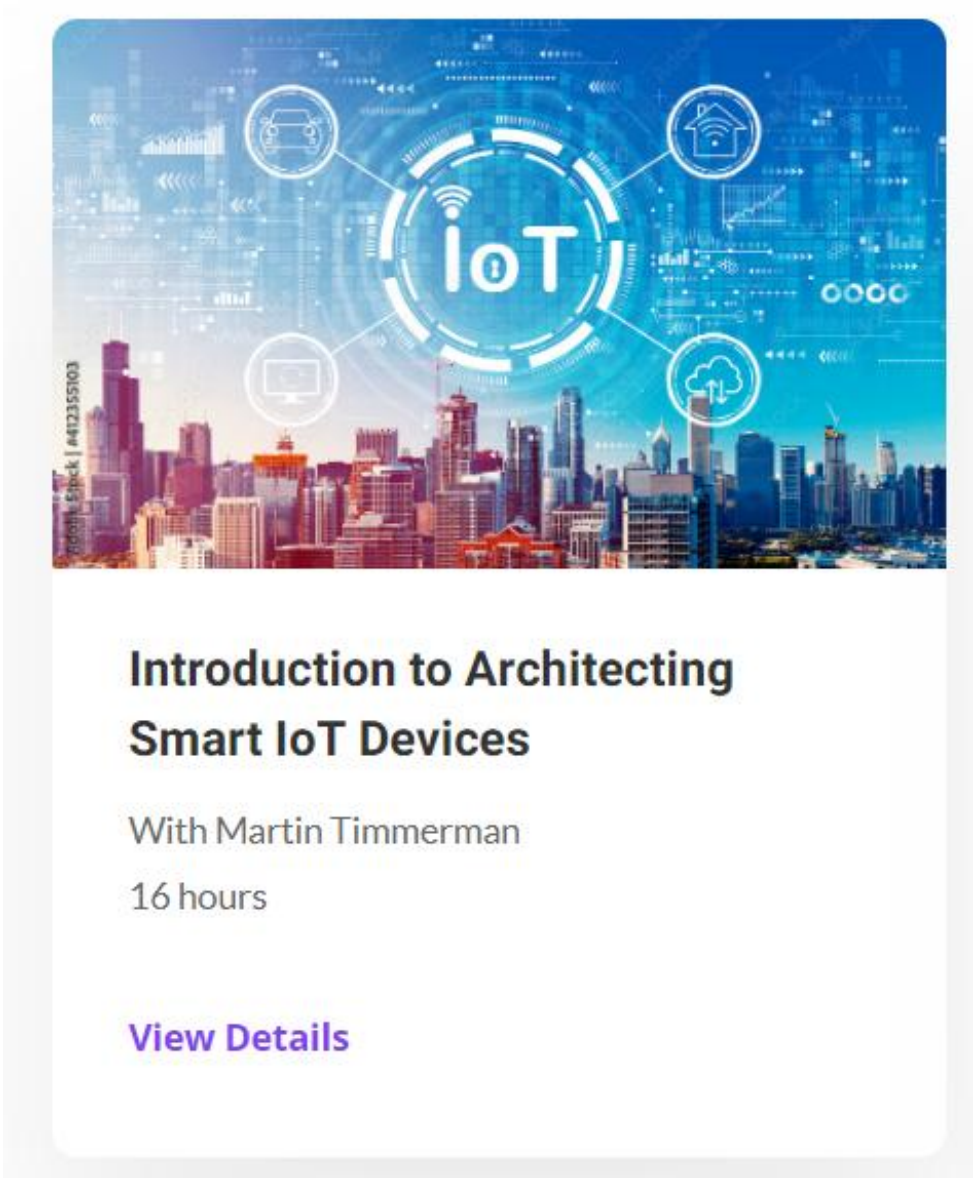


Image Placement

Course Featured Image: Large image at the top, visually representing the course content.



Video Overlay:

Images Throughout Course: Relevant images placed near related text for better understanding.

Thank you for taking the time to provide your feedback.

Your insights are invaluable in helping us improve our website and create a better learning experience for all users.