(RESEARCH ARTICLE)

Applying technology to enhance the effectiveness of teaching and learning Information Technology at Nha Trang College of Technology in the era of 4.0

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Abstract

In the era of 4.0, technology is not only a part of daily life but has also become an indispensable part of teaching and learning. Visualization Tools, Cloud Computing, and Artificial Intelligence (AI) are breakthrough technologies, especially AI with its notable achievements in recent years such as ChatGPT and Github Copilot, have changed the way we live, work, teach, and learn. In this article, I will provide an overview of visualization tools, cloud computing, and artificial intelligence and how to apply some of these tools to enhance effectiveness in vocational training in Information Technology at Nha Trang College of Technology during the current fiercely competitive labor market.

1. Introduction

The Information Technology profession at Nha Trang College of Technology mainly includes courses oriented towards basic programming (C, Python, C#, Data Structures) and application programming (web, .NET and mobile devices). With more than 10 years of experience teaching basic and application programming such as ASP.NET, React, NodeJS, React Native…, one of my biggest passions is to find tools that support teaching in the most effective way. Effectiveness to me means that those tools must ensure 3 objectives:

- Create interest, liveliness in conveying knowledge from the teacher as well as grasping knowledge from the learner.
- Convenient interaction between teacher and learner, enhancing teamwork skills, communication between learners in the process of doing projects, assignments.
- Contribute to improving efficiency in teaching activities (preparing lectures, assignments, reference materials.) and learning activities (understanding lessons, doing assignments, self-study,…).

In the 4.0 era, technology is increasingly developing, visualization tools, cloud computing and artificial intelligence (AI) are widely used in teaching and learning programming and information technology at colleges and universities in general and at Nha Trang College of Technology in particular.

These tools help teachers and students understand and learn more easily and effectively.

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2. Overview of Tools

2.1. Visualization Tools

Information technology and programming are crucial and rapidly developing fields in the era of Industry 4.0. However, teaching and learning these domains pose numerous challenges, especially for beginners. One of the main difficulties understands the functioning of programs, algorithms, and data structures. To address this issue, the use of visualization tools can bring many benefits to both educators and learners ([1, 2, 3, 4]).

Visualization tools are software, applications, or websites that allow users to visually observe the execution process of programs, algorithms, and data structures. This is achieved through the use of charts, graphs, tables, images, colors, sounds, or other techniques. Many tools are employed in introductory programming education, such as Trinket, Python Tutor ([4]), or data structures and algorithms tools like Willow ([3]). Finn Eivind Aasen [1] and Stanislav Litvinov [2] provide lists of tools, their advantages and disadvantages, and how to appropriately apply them in programming education activities for training programmers, software engineers, and computer scientists.

2.2. Cloud Computing

One of the main challenges in teaching and learning basic programming or application programming at Nha Trang College of Technology, specifically, or at programming training institutions and computer science engineering schools in general, includes:

- Installing, configuring, and managing necessary resources such as computers, software, networks, storage, security, etc.
- Interaction between educators and learners. For example, if an educator wants to check or support a learner, they may need to physically be present at the learner's location.
- Interaction among learners in collaborative project exercises.

To address this issue, the use of cloud computing tools can bring many benefits to both educators and learners ([9, 10, 11, 12]).

Cloud computing tools are software, applications, or websites that allow users to access and use information technology resources over the internet without the need for installation or management on personal computers. An outstanding application of cloud computing tools is Github ([9, 12]), a website that enables users to store, manage, share, and collaborate on the source code of programming projects. Github also provides the Gist tool, allowing users to embed code snippets into online documentation.

Another application of cloud computing is online Integrated Development Environments (IDEs) ([13]), such as CodePen, CodeSandbox, Replt.it, JDoodle, etc. These websites allow users to write, run, and test programming code directly in the browser without the need for any software installation. Remarkably, these tools allow embedding into online documentation to illustrate code snippets, concepts, and facilitate learners in quickly checking code or concepts on any device with an internet connection.

Although somewhat outdated, another effective form of cloud computing is being used in online learning platforms like KhanAcademy, W3Schools, freeCodeCamp, which is Content Delivery Network (CDN) - a group of distributed servers worldwide to deliver internet content quickly and efficiently ([14]).

2.3. Artificial Intelligence (AI)

AI tools such as ChatGPT and Github Copilot are applications of artificial intelligence in the field of information technology and programming. ChatGPT is a chatbot platform capable of answering questions on various topics, contributing to improved performance in teaching activities (lecture preparation, exercises, reference materials, etc.) and learning activities (understanding lessons, completing exercises, self-learning, etc.) ([5, 6, 8]).

GitHub Copilot ([6, 7]) is a programming assistance tool that can suggest code snippets and functions based on the context and intention of the user, facilitating faster and potentially more effective programming learning.

3. Applying Tools in Teaching and Learning Information Technology at Nha Trang College of Technology

3.1. Cost

The tools mentioned in the article mostly come with both free and paid options (for users interested in larger projects, organizations, businesses). The following applied tools are utilized from the free options, eliminating costs for both educators and learners. Despite being free, these tools provide comprehensive features that support well in educational and vocational training environments.

3.2. Application of Tools

*3.2.1. Visualization Tools*

3.2.1.1. Python Tutor Tool [15]

At Nha Trang College of Technology, the primary visualization tool that I and my colleagues use is Python Tutor, a website that allows users to input source code and visualize the program's execution steps, as well as the state of variables, functions, objects, and memory. Utilizing the Python Tutor tool involves the following steps:

- Access https://pythontutor.com/
- Choose the language, for example, Python
- Write the program code and click the "Visualize Execution" button
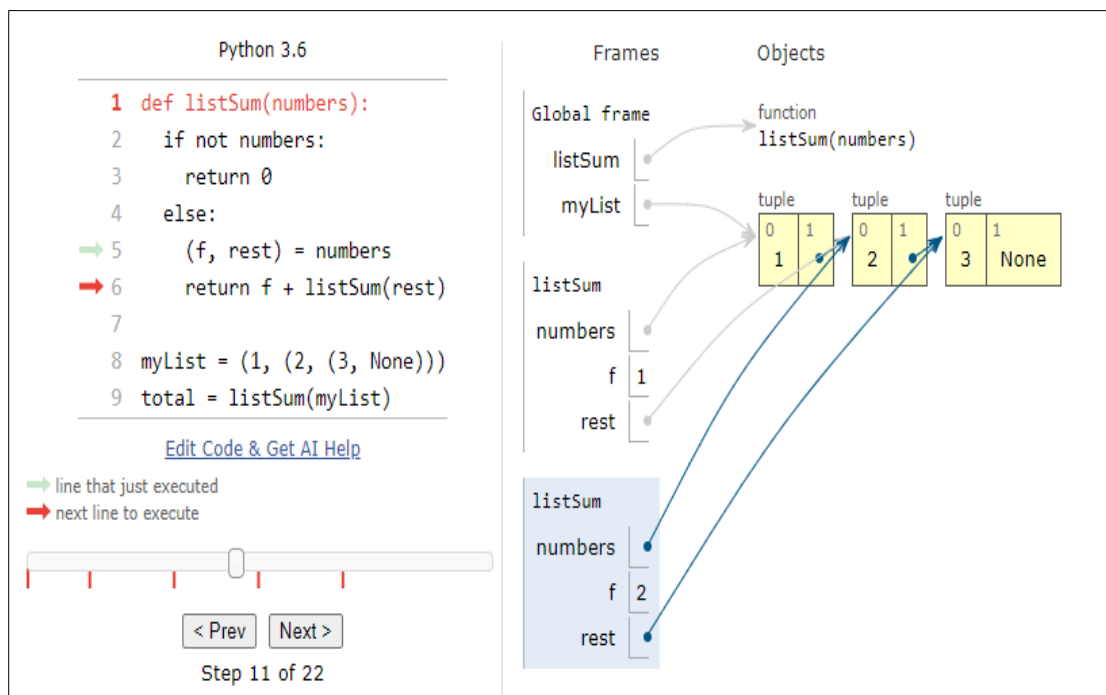
Figure 1 Visual Interface of the Python Tutor Tool for visualizing programs written in the Python language

- To share the program, click the "Generate permanent link" button at the bottom of the page.
- To embed the program into an online document, click the "Generate embed code" button at the bottom of the page.
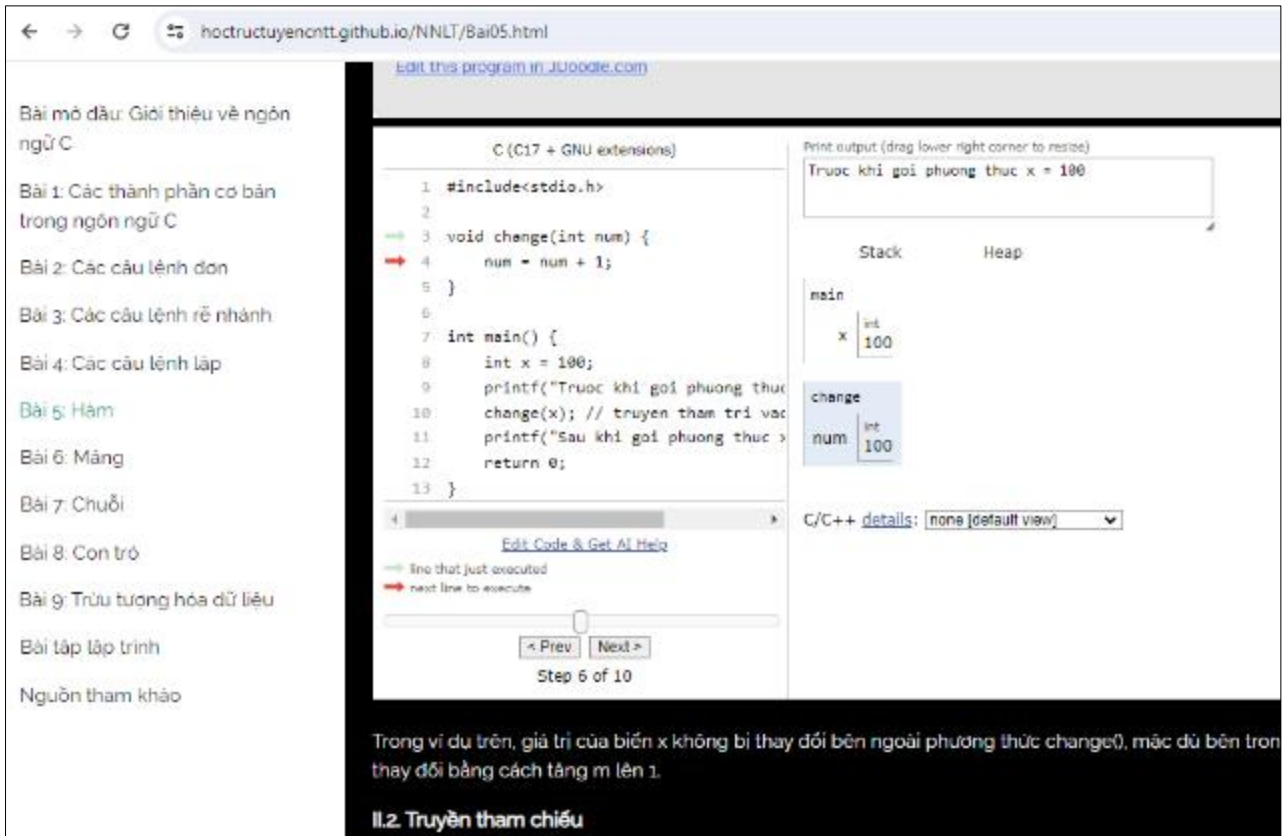
Figure 2 Embedding the Python Tutor Tool in an online document for the C programming language (Appendix)

Utilizing the Python Tutor Tool in teaching and learning is described as follows

Table 1 Using the Python Tutor in teaching and learning activities

Subject	Teaching Activities	Learning Activities
C Programming Language	Illustrate the operation mechanisms of programs, algorithms, and data structures (Figure 1).	Write code, run and test programs, algorithms, and data structures.
Data Structures and Algorithms		
Python Programming Language	Embed in online teaching materials to visually illustrate examples using Generate embed code (Figure 2).	Collaborate in groups or request remote support by sharing program links with team members, instructors using Generate permanent link.
JavaScript Programming Language	Support remote assistance and evaluation through program links shared by students.	

3.2.1.2. Advantages and Disadvantages of the Python Tutor Tool

Advantages

- Helps learners grasp the operation mechanisms of programs, algorithms, and data structures in a clear and understandable manner. This aids in enhancing programming logic, analysis, and problem-solving skills, as well as avoiding common errors.
- Easy integration into online materials allows educators to illustrate abstract and complex concepts dynamically, attracting the attention and interaction of learners, as well as assessing the effectiveness of teaching.
- Assists learners and educators in saving time and effort when writing, running, and testing programs, algorithms, and data structures. This helps focus on essential and crucial content.
- Facilitates remote collaboration, support, and evaluation.
- Completely free to use.

Disadvantages

- Learners may become overly reliant on visualization tools and lose the ability to independently think through programming concepts.
- Does not cover all programming situations and issues comprehensively.
- Visual tools cannot entirely replace the learning and understanding of fundamental programming principles

3.2.2. Cloud Computing

3.2.2.1. GitHub Tool [16]

At Nha Trang College of Technology, the GitHub tool is utilized by me and my colleagues in most programming-related courses, including application programming (web, mobile). Using the GitHub tool involves the following steps:

- Access https://github.com/
- Log in (or create a new account if not already done).
- Visit https://git-scm.com/ to download and install the Git tool.
- Use the Git tool to share, update, and manage projects on GitHub.
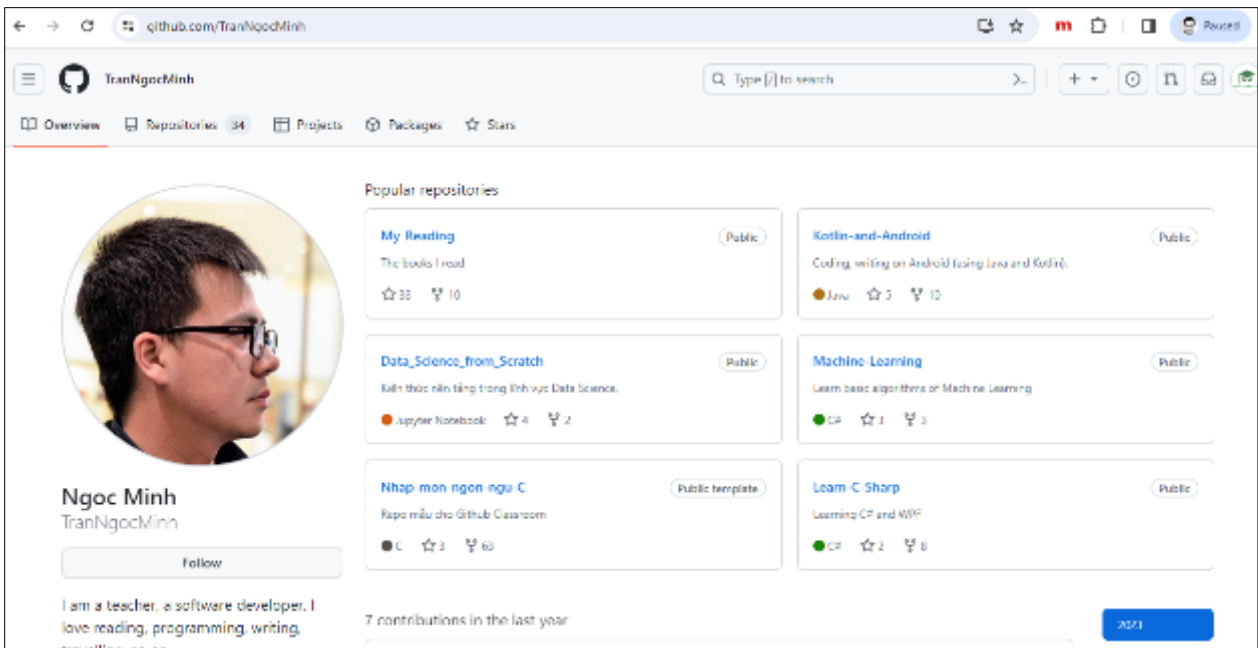
Figure 3 GitHub Interface

Utilizing the GitHub tool in teaching and learning is described as follows:

Table 2 Using the GitHub tool in teaching and learning activities

Subject	Teaching Activities	Learning Activities
In most programming-related courses, including application programming (web, mobile)	Store documents, source code, lectures, and projects. Share documents and lectures online using GitHub Pages and Gist features (Appendix). Collaborate and support students. Track project development and assess student tasks. Introduce projects and open-source communities.	Store and manage source code for programming projects. Learn from open-source projects. Collaborate on project development or provide support. Track personal development. Share knowledge. Explore job opportunities by building online profiles during the learning process.

*3.2.2.2. Online Integrated Development Environments (IDEs)*

At Nha Trang College of Technology, online IDEs are utilized by me and my colleagues in most programming-related courses, including application programming (web, mobile). The online IDEs used are:

Table 3 Subjects and the online IDEs

Subject	Online IDEs
C Language, Python Language, JavaScript Language, Data Structures and Algorithms	JDoodle (https://www.jdoodle.com/) Replit (https://replit.com/)
Website Design, Client-side Application Development (React, Redux), Server-side Application Development (NodeJS, Express, MongoDB) Mobile Programming (React Native)	CodePen (https://codepen.io/) Glitch (https://glitch.com/) Replit (https://replit.com/) CodeSandbox (https://codesandbox.io/) (Figure 4)
	Expo (https://expo.dev/)

Using online IDEs involves the following steps:

- Access the website of the IDE you want to use.
- Log in (or create a new account).
- Choose a project or programming language.
- Begin working on the project.
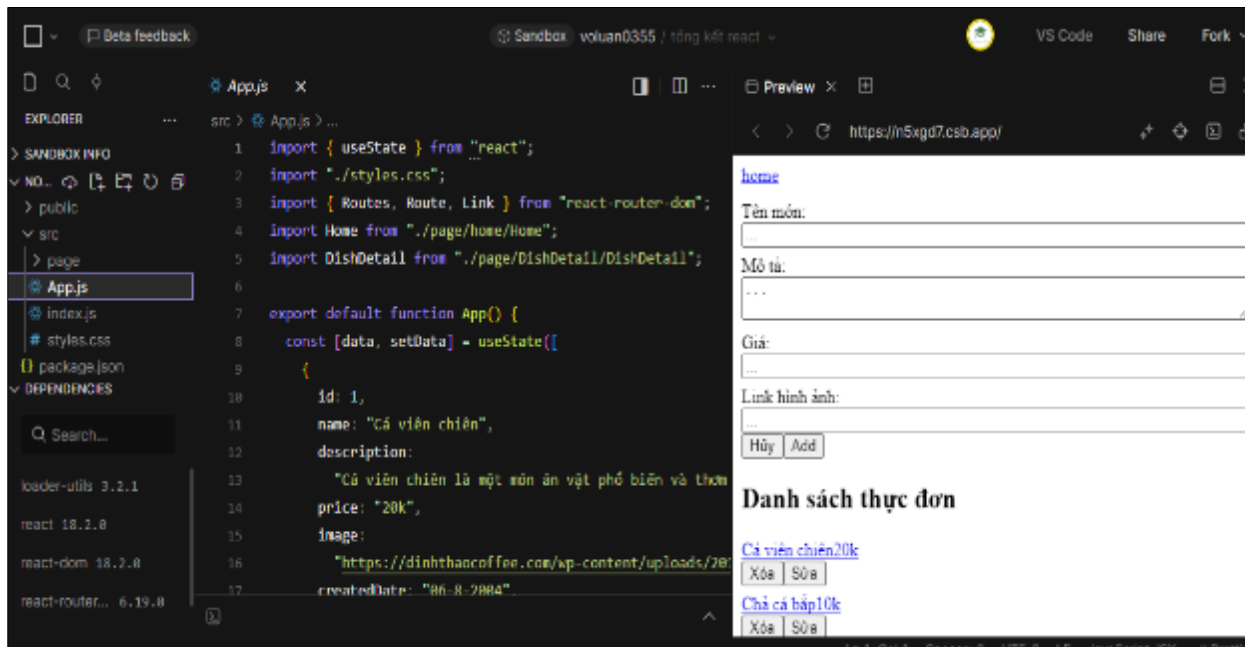
Figure 4 Project Interface from CodeSandBox IDE [19]

Teaching and learning activities are described as follows:

Table 4 Using the online IDEs in teaching and learning activities

| Teaching Activities	Learning Activities
Illustrate the operation mechanisms of programs, algorithms, data structures, and projects.	Write code, run, and test programs, algorithms, data structures, and projects.
Embed in online teaching materials to visually illustrate examples (Figure 5).	Collaborate in groups or request remote support by sharing program links with team members, instructors.
Support remote assistance and evaluation through program links shared by students.	Store and manage source code for programming projects.
Store documents, source code, lectures, and projects.	Learn from open-source projects.
Track project development and assess student tasks.	Track personal development.
	Share knowledge.
	Explore job opportunities by building online profiles during the learning process.
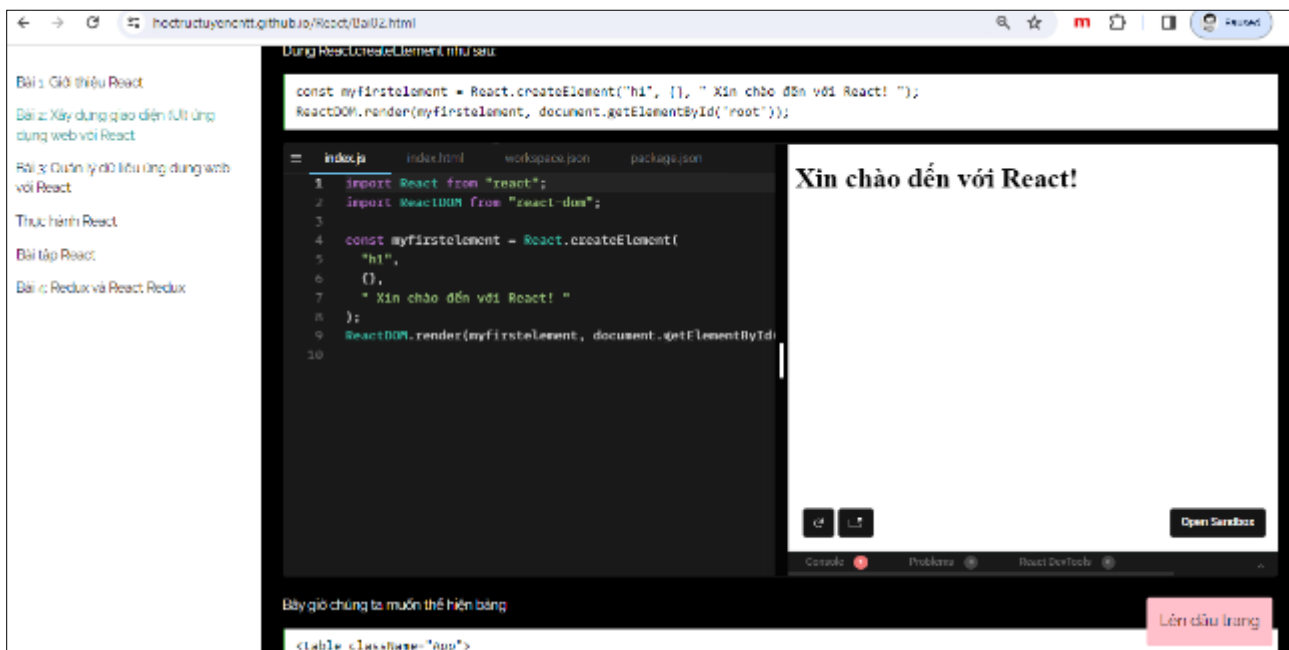
Figure 5 Interface of Embedded IDE in Online Documentation

3.2.2.3. Content Delivery Networks (CDNs)

We use CDNs to build online tools with the following advantages:

- User-friendly interface on all devices.
- Can practice coding with any device such as smartphones, tablets, laptops, desktop computers as long as there is an internet connection.
- Efficient support for online teaching and learning, remotely.
- Easy integration with digitalized learning materials, textbooks, and relevant lecture slides.
- Effective support for reviewing end-of-course exams and graduation exams.

One of the frequently used tools is the online SQL query tool (Figure 6, [A4]) with a database suitable for the content of review and teaching at our institution.
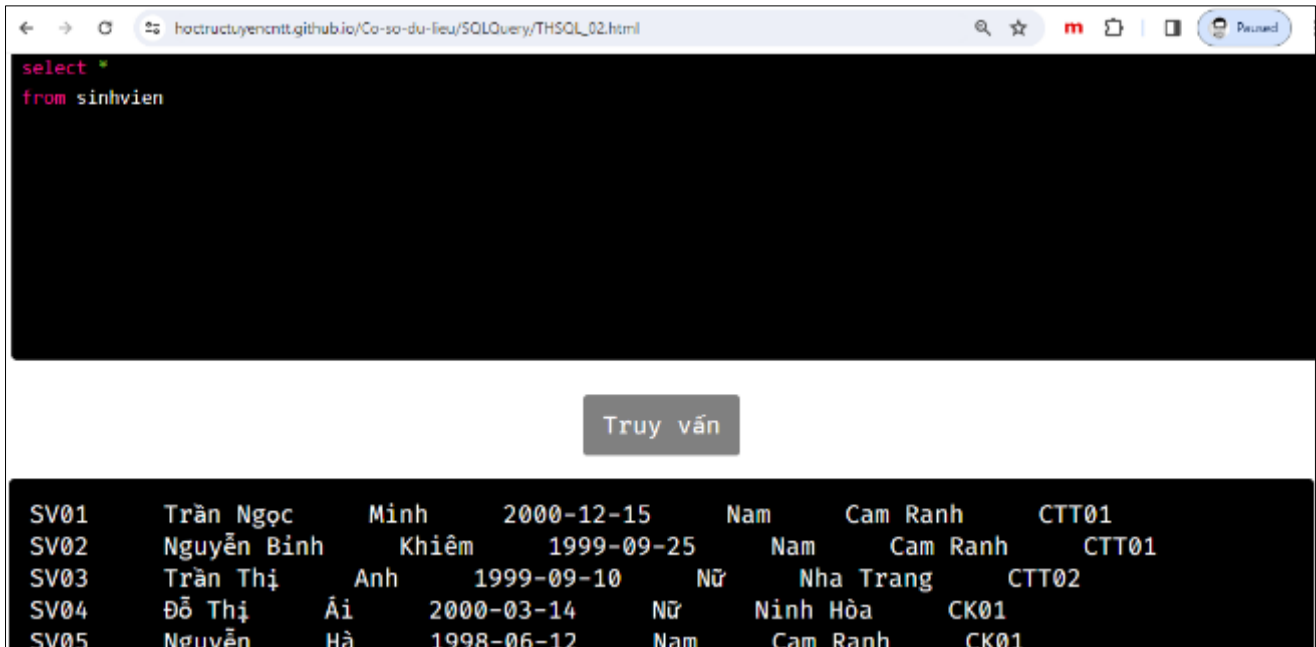
Figure 6 Interface of Online SQL Query Tool

3.2.2.4. Pros and Cons of Cloud Computing Tools

Pros

- Saves time, costs, and effort in installing, configuring, and managing information technology resources. Both educators and learners only need a device with internet connectivity, such as a computer, phone, or tablet, to access and use cloud computing tools easily and quickly.
- Allows a focus on learning programming concepts, languages, and techniques without worrying about technical or system issues. Learners can test, practice, and improve their programming skills flexibly and creatively without facing technological barriers or limitations.
- Facilitates learning, networking, and collaboration within the programming community. Learners can view, copy, modify, and provide feedback on the source code of others, as well as share, comment, and contribute to collaborative programming projects. This helps learners expand their knowledge, experience, and relationships in the field of information technology.

Cons

- May be challenging for beginners and requires a certain learning curve.
- Using online platforms requires caution regarding security and privacy issues.
- Cloud computing relies on internet connectivity.
- Fees may apply for large-scale, real-world projects.

3.2.3. Artificial Intelligence (AI)

3.2.3.1. ChatGPT (3.5 and 4) [17]

In the process of teaching information technology, I and some colleagues have boldly utilized AI tools in preparing lectures, exercises, reference materials, etc. At the same time, we encourage students to use these tools as virtual assistants to gain a better understanding of the lessons, complete exercises, and engage in self-directed learning.
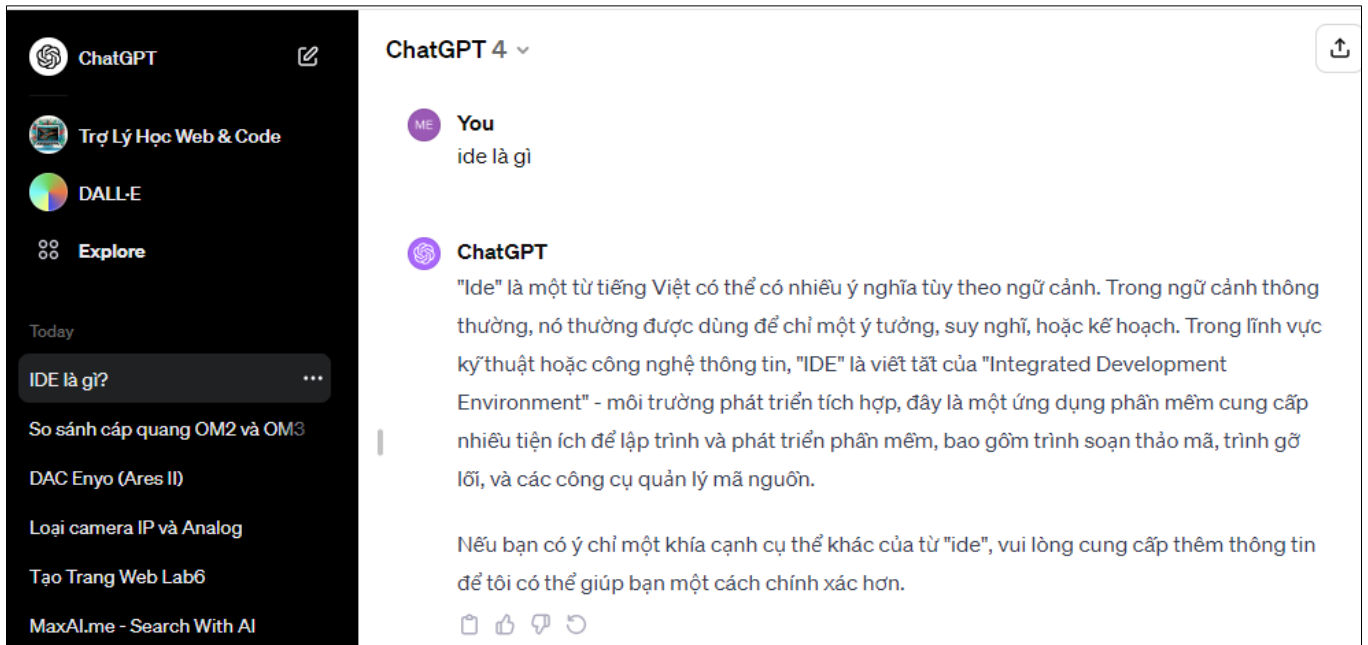
Figure 7 ChatGPT Interface

3.2.3.2. Github Copilot [18]

A programming assistance tool that can suggest code snippets and functions based on the context and intention of the user, facilitating faster and potentially more effective programming learning.
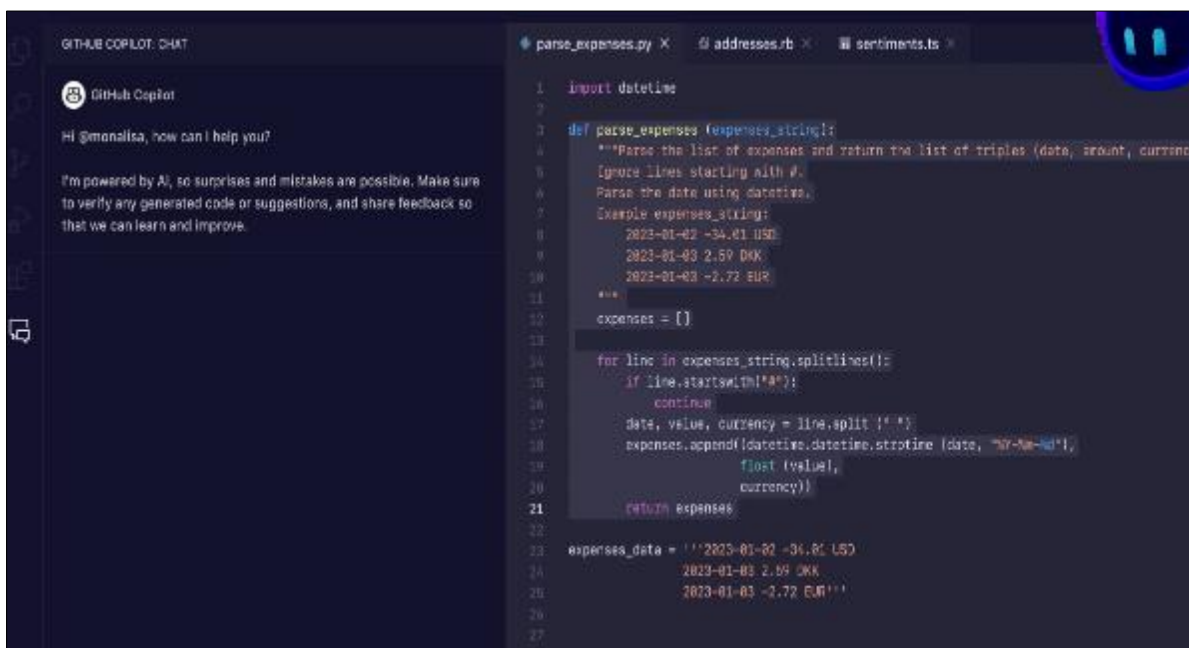

Figure 8 Github Copilot Interface

3.2.3.3. Advantages and Disadvantages

Advantages

- Enhances learner interaction and engagement. ChatGPT, Bing Chat can provide quick and friendly answers, making learners feel comfortable and more interested in the learning content. GitHub Copilot can help learners save time and effort in programming, providing useful suggestions aligned with the learner's goals.

- Improves learners' skills and knowledge. ChatGPT can keep learners updated on the latest and accurate information related to information technology and programming, helping them expand their knowledge and stay current. GitHub Copilot can support learners in learning programming techniques and tricks from open-source projects on GitHub, enhancing their programming skills.
- Facilitates personalized and flexible learning. ChatGPT can adjust the style and difficulty of questions and answers according to the learner's needs and abilities, enabling learners to learn at their own pace and preferred methods. GitHub Copilot can work with various programming languages and development environments, allowing learners to choose and experiment with tools and projects based on their interests and goals.

Disadvantages

Alongside the advantages, several drawbacks have been encountered or mentioned in the literature ([5, 6, 8]), such as:

- Limitations in handling complex and creative requests. ChatGPT, Bing Chat may struggle with answering questions that require high-level analysis, evaluation, and inference, or questions with multiple nuances and implicit meanings. GitHub Copilot may struggle to generate entirely new code snippets and functions or those with specific and unique requirements.
- May introduce errors and quality and safety risks. ChatGPT may provide inaccurate, outdated, or unreliable information due to being trained on a large amount of uncurated and meticulously selected data. GitHub Copilot may generate code snippets and functions containing errors, vulnerabilities, or copyright violations, as it learns from unverified and unassured open-source code.
- May reduce learner effort and responsibility. ChatGPT may lead learners to rely too much on its answers, diminishing the need for self-exploration and critical thinking. GitHub Copilot may encourage learners to copy or use its code snippets and functions without having to write or fully understand them.
- Cost for upgraded versions.

3.2.3.4. The new context and recommendations

The remarkable development and widespread use of AI tools such as ChatGPT or GitHub Copilot have raised concerns and debates within the programming and information technology teaching community ([6]). In this new context, to adapt to and coexist with AI tools, educators like us need to:

- Grasp and update knowledge about AI tools, how to use them, and their applications in teaching and learning. Educators can participate in courses, workshops, and educational technology forums, especially those related to AI tools, to learn and exchange experiences with experts and colleagues.
- Utilize and optimize the advantages of AI tools but not entirely depend on them. Educators can use AI tools to support lesson preparation, content presentation, assessment, and interaction with students, but should not replace their role and responsibility with AI tools.
- Identify and address the drawbacks and risks of AI tools, while educating and reminding students about these points. Educators can assess the quality and safety of information, code snippets, and functions provided by AI tools, and rectify or report errors and issues if any. Educators can also help students recognize and avoid the negative consequences of using AI tools, such as loss of control, loss of creativity, irresponsibility, copyright infringement, and harm to others.

Encourage and guide students to use AI tools selectively, purposefully, and responsibly. Educators can introduce and recommend AI tools suitable for the content, goals, and learning audience, guiding students on how to use them effectively and safely. Educators can also create interesting and challenging activities and exercises that require students to think critically, be creative, and collaborate, rather than relying solely on AI tools.

Appendix (Some Integrated Online Teaching and Learning Tools for Information Technology Education at Nha Trang College of Technology)

- Teaching materials for programming in the IT profession at Nha Trang College of Technology: https://hoctructuyencntt.github.io/NNLT/Baimodau.html
- React teaching materials for the IT profession at Nha Trang College of Technology: https://hoctructuyencntt.github.io/React/Bai01.html
- React Native teaching materials for the IT profession at Nha Trang College of Technology: https://hoctructuyencntt.github.io/ReactNative/Bai01.html

- Online SQL language practice tool for teaching SQL query language in the IT profession at Nha Trang College of Technology: https://hoctructuyencntt.github.io/Co-so-du-lieu/SQLQuery/index.html

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4. Conclusion

Visualization tools or cloud computing may not be new, but the breakthrough development of AI tools like ChatGPT, Bing Chat, or GitHub Copilot significantly impacts various aspects of life in general and, specifically, in the field of education. These tools come with their advantages and disadvantages, as well as hidden risks and consequences. In the era of Industry 4.0, educators need to grasp and update their knowledge about these tools, utilize and optimize their advantages, identify and address their drawbacks and risks, and encourage and guide students to use them selectively, purposefully, and responsibly. This is essential for improving the quality and effectiveness of teaching and learning information technology and programming at Nha Trang College of Technology.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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