

Generative ai tools in software teaching and learning: implications for business education

Herramientas de IA generativa en la enseñanza y el aprendizaje del software: implicaciones para la educación empresarial

Anand Jeyaraj*

<https://orcid.org/0000-0003-3691-881X>

Wright State University (USA)

Vikram Sethi

<https://orcid.org/0009-0008-8272-6441>

Wright State University (USA)

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*Corresponding author: anand.jeyaraj@wright.edu

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ABSTRACT

The widespread introduction and availability of generative artificial intelligence (GenAI) tools have transformed how individuals use tools for their tasks. GenAI tools hide the complexities in tasks from individuals while allowing them to complete necessary tasks. Despite such advantages, it is unclear if they are desirable in learning environments since they disrupt the learning process as well as the outcomes. This paper shows how GenAI tools question the traditional teaching and learning process through the engagement, reinforcement, and assessment stages. Based on data preparation, data querying, and data processing activities taught in an undergraduate business course, this paper illustrates how GenAI tools impact learning by enabling students to skip problem-solving and critical thinking activities. While GenAI tools may yield productivity enhancements, they also further conditions in which individuals' intellectual growth and lifelong learning capabilities may be compromised, thus weakening societies in the long run. The need to rethink traditional teaching

and learning as blended methods to foster student learning is raised if GenAI tools are here to stay and expected to be used in educational settings.

Keywords. Generative Artificial intelligence, GenAI, Teaching, Learning, Blended, Education

RESUMEN

La introducción y disponibilidad generalizada de herramientas de inteligencia artificial generativa (GenAI) han transformado la manera en que los individuos utilizan herramientas para sus tareas. Las herramientas de GenAI ocultan las complejidades de las tareas a los usuarios, permitiéndoles completarlas de manera eficiente. Sin embargo, a pesar de estas ventajas, no está claro si su uso es deseable en entornos de aprendizaje, ya que alteran tanto el proceso como los resultados del aprendizaje. Este artículo analiza cómo las herramientas de GenAI cuestionan el proceso tradicional de enseñanza y aprendizaje a través de las etapas de participación, refuerzo y evaluación. A partir de actividades de preparación, consulta y procesamiento de datos enseñadas en un curso de negocios a nivel de licenciatura, se ilustra cómo las herramientas de GenAI impactan el aprendizaje al permitir a los estudiantes omitir actividades de resolución de problemas y pensamiento crítico. Si bien las herramientas de GenAI pueden generar mejoras en la productividad, también crean condiciones que pueden comprometer el crecimiento intelectual y la capacidad de aprendizaje continuo de los individuos, debilitando así a las sociedades a largo plazo. Dado que las herramientas de GenAI han llegado para quedarse y se espera que sean utilizadas en entornos educativos, surge la necesidad de replantear los métodos tradicionales de enseñanza y aprendizaje como enfoques híbridos que fomenten el aprendizaje de los estudiantes.

Palabras clave. Inteligencia artificial generativa, GenAI, Enseñanza, Aprendizaje, Híbrido, Educación

INTRODUCTION

Generative artificial intelligence (GenAI) has engendered significant changes in how users interact with technologies. Several general-purpose GenAI tools such as ChatGPT and special-purpose GenAI tools such as Dall.E (images), DeepAI (videos), Soundraw (music), and SlidesGPT (presentations) have been introduced in the market in recent times. GenAI tools enable user interaction through an interface that supports natural language conversations typically used by humans and responds with new content generated based on the user prompts. These GenAI capabilities have also been integrated into various technology environments, including search engines (Microsoft Bing), productivity tools (Microsoft CoPilot), and software development platforms (GitHub CoPilot) to generate new content for human use. For instance, Microsoft CoPilot helps with information search, technical guidance, and document summaries, whereas GitHub CoPilot generates new source code in high-level programming languages to assist with software development (Bird et al. 2022; Finnegan 2023; Prather et al. 2023).

However, it is unclear if GenAI tools are always desirable¹ in the context of education. GenAI tools often shield students from gaining the knowledge to be applied in handling tasks, the complexity of the tasks to be completed, the steps needed to complete the tasks, the problem-solving and critical thinking skills required to identify potential solutions, and the opportunity to develop lifelong learning skills. This typically contradicts traditional expectations that students will invest in learning to acquire and enhance their skills and knowledge relevant to the specific domains

¹ GenAI could be useful in certain environments. In work settings, for instance, GenAI tools may offer productivity gains that may be coveted since workers are expected to efficiently complete tasks and quickly accomplish goals.

of study and equip themselves for their professional careers in the workforce, which will eventually better societies.

This paper describes the challenges imposed by GenAI tools on business students learning the use software tools to complete various tasks and highlights the extent to which GenAI tools may question the notions of traditional teaching and learning. Using three examples—Microsoft Excel for data handling tasks, Microsoft Access for data querying tasks, and Python for data processing tasks—positioned in the context of the engagement, reinforcement, and assessment stages of the teaching and learning process, this paper shows how GenAI tools (using Microsoft CoPilot as the example) disrupt the teaching and learning experience. It can be seen that GenAI tools may serve as a source of knowledge, provide potential solutions along with explanations, and allow tasks to be completed much faster than is possible with traditional methods.

The remainder of the paper is organised as follows. The next section presents an overview of traditional teaching and learning along with its general goals, which is followed by a section that describes GenAI in the context of higher education. The subsequent section illustrates the use of GenAI tools that may be experienced in higher education environments dealing with software. The next section reimagines teaching and learning for the long term by considering “blended” methods involving both traditional and GenAI methods. The conclusion section ends with a call for introspection of teaching and learning methods and the mindful use of GenAI tools.

TRADITIONAL TEACHING AND LEARNING

The overall process of teaching and learning within classrooms can be abstracted as multiple stages shown in Figure 1. These stages primarily represent the times involving student-teacher interactions² during the semester.

Figure 1. Teaching and Learning process



Engagement. The engagement stage deals with the theoretical exposition or presentation of the specific knowledge about the domain students need to know or learn. This raises the question as to how it can be accomplished. Different approaches to engage students have been proposed in prior literature and can be grouped into two broad categories. The first category represents instructor-centred approaches, which focus on the instructor and place considerable emphasis on instructors conveying the relevant knowledge to students (Saulnier et al. 2008). Instructors are generally considered the main source of knowledge and transmit the knowledge to students who passively absorb it. The second category represents learner-centred approaches, which focuses on empowering students and facilitating them to acquire knowledge (e.g., Griffiths et al. 2007; Zhang et al. 2013). Students are expected to take a more active role in their learning, which may be facilitated by experiential learning, active learning, cooperative learning, and transformative learning methods (e.g., Bonwell and Eison 1991; Cooper and Mueck 1990; Dillbenbourg 1999; Kolb 1984; Mezirow 2006). Despite the differences, these methods strive to motivate students to take

² This process does not show other stages such as preparation (which happens prior to the engagement stage) or improvement (which happens after the assessment stage) because they do not necessarily involve instructor interactions with students and are typically done between semesters.

control of their learning experiences and are typically favoured over instructor-centred approaches (Zhang et al. 2013).

Reinforcement. The reinforcement stage deals with the mechanisms by which students can learn how to apply the knowledge gained and develop or enhance the necessary skills. Different mechanisms have been identified to reinforce student learning in classrooms. Instructors may use lectures and assignments when adopting instructor-centred approaches. In contrast, other methods such as games (e.g., jeopardy, crossword, debates), reflection (e.g., journals), multimedia (e.g., audio, video), and collaboration (e.g., crowdpolling, origami) may be applied in learner-centred approaches to increase student engagement and learning (Massey et al. 2005; McKinney et al. 2023; Mitri et al. 2017; Mok 2014; Nagle et al. 2023; Sibona et al. 2018; Woods 2020; Zhang et al. 2013). Instructors could provide scaffolds to progressively build students' knowledge, skills, and confidence as they grapple with the new content (Belland et al. 2022). These activities enable students to assimilate knowledge, enhance problem solving and critical thinking skills³, and develop skills for lifelong learning (MacKenzie 2023; Prince 2004; Schloemer & Brennan 2006). Students also develop the skills and abilities to transfer knowledge they gained in instructional settings to their professional settings (Reginato et al. 2022).

Assessment. The assessment stage deals with how students demonstrate their knowledge and skills. Various methods have been recommended and designed to assess classroom student learning and performance. These may be classified into summative assessment and formative assessment methods with different purposes and goals. Summative assessments aim to measure student learning as an outcome when the instruction is completed (Kibble 2017). They are conducted at the end of the course or the semester and document the learning accomplished by students in the recent past (Ishaq et al. 2020). Formative assessments are aimed at adapting instruction to help improve student learning and typically carried out during the instructional process (Shepard 2019). They are conducted throughout the course to assess student learning and be used to incorporate changes to the content and delivery of the course (Mubayrik 2020). These assessments include feedback on the gap between what students have mastered and what they still need to learn to enhance performance (Opdecam & Everaert 2022). While both summative and formative assessments make useful contributions by themselves, it is possible to incorporate both in courses to facilitate student learning and overall performance.

The use of GenAI tools disrupts typical activities within the engagement-reinforcement-assessment stages in the overall teaching and learning process. More specifically, the domain knowledge to be understood by students during the engagement stage becomes unclear (e.g., what knowledge should be imparted to students if the GenAI tools complete the necessary tasks without student intervention?), the specific methods to be learned or skills to be gained by students during the reinforcement stage become redundant (e.g., what is the point of students having to learn various techniques if the GenAI tools can complete the tasks?), and the need to evaluate learning of students during the assessment stage becomes questionable (e.g., what is being assessed of students if the GenAI tools complete the tasks instead of students?)⁴. Clearly, students cannot apply critical thinking and problem solving skills, exercise and enhance their intellectual

³ Problem solving refers to the thinking and planning necessary to reach outcomes starting with an initial state and moving towards a goal (Butterworth & Thwaites 2013) while critical thinking describes the ability to analyze and evaluate the soundness and credibility of arguments regarding problems in reaching conclusions through deduction (Tiruneh et al. 2014). Both these skills are valued in learning environments as they contribute to task completion. Mathee & Turpin (2019) offer a broader discussion of both critical thinking and problem solving.

⁴ This argument assumes that acquisition and demonstration of knowledge and skills by students is valuable and are primary considerations in the learning process. Otherwise, these disruptions may be considered moot and the use of GenAI tools not so problematic.

abilities, or develop lifelong learning skills if the GenAI tools disrupt the teaching and learning process.

GENERATIVE ARTIFICIAL INTELLIGENCE IN EDUCATION

GenAI tools possess the ability to not only provide responses to human natural-language questions but also generate new textual and multimedia content in different forms mimicking the natural intelligence and creativity of humans to the extent that the new content cannot be fully distinguished from human output (Lim et al. 2023; Wood & Moss 2024). The ability of GenAI tools to mimic human output is made possible by algorithms trained on large volumes of data employing advanced machine learning and deep learning techniques (Hashmi & Bal 2024). The training dataset is recognized to be particularly important since the results produced by GenAI tools are influenced by it (Walczak & Cellary 2023). GenAI tools are capable of creating new data by deriving from the probability distribution of existing data (Mittal et al. 2024). GenAI is susceptible to hallucinations such that the generated content may not always be plausible and could be misaligned with truth (Lee et al. 2024; Walczak & Cellary 2023). However, GenAI is capable of handling complex instructions and producing creative output, answering questions, and summarizing text that require higher-order thinking (Gupta et al. 2024).

The role of GenAI in education has received considerable attention. GenAI enables interactive learning, enhances language support, promotes accessibility, enhances learning efficiency, and improves student engagement (Ahmed et al. 2024; Nzenwata et al. 2024). GenAI is expected to offer personalized and unique attention to all students, which sometimes may be lacking in traditional settings, especially in large classes, in which instructors may not be able to extend attention to everyone (Mittal et al. 2024). However, there are concerns about academic dishonesty potentially engendered by GenAI that undermines learning (Hashmi & Bal 2024). Researchers have suggested ways in which educational institutions may enact policies and encourage the responsible adoption and use of GenAI tools (Moore & Lookadoo 2024; Valcea et al. 2024). While there are calls to reimagine education by embracing and not shunning GenAI tools (Acar 2024; Hyde et al. 2024; Lim et al. 2023), there is also recognition that indiscriminate use of GenAI could negatively impact long-term growth and result in a net-negative effect on learning since the foundational cognitive skills and processes are handled by GenAI (Valcea et al. 2024). Illustrations of the disruptions enabled by GenAI tools are described in the next section.

ILLUSTRATIONS OF TRADITIONAL LEARNING VS. GENAI TOOLS

GenAI tools are illustrated and contrasted with traditional teaching and learning using examples from a course taken by undergraduate students in a large university in midwestern United States. The introductory course on business analytics is the first course in a sequence that helps students learn concepts and techniques on acquiring, preparing, and analysing data to facilitate business decision-making. The outcomes of for the course include: “prepare data from different sources for analysis,” “develop scripts to handle data from different sources,” and “analyze and visualize data for business decision-making.” In the course, students learn different software tools, including Microsoft Excel, Microsoft Access, and Python, that can be used for specific purposes such as data preparation, querying, and data processing consistent with the learning outcomes.

Data preparation using Excel

Data preparation refers to activities to get the data ready for analysis and is more commonly known as the Extract-Transform-Load (ETL) process (Vassiliadis 2009). A common preparation

activity⁵ is the transformation of a combined attribute into its constituent (or atomic) attributes. An example could be a United States ADDRESS attribute that can be split into STREET, CITY, STATE, and ZIPCODE attributes.

To help students understand data preparation, they may be introduced to: a) the different string handling functions (e.g., LEFT, RIGHT, MID) used to split the address attribute into its constituents, b) the role of delimiters such as the comma in the combined address field, and c) the construction of formulas involving the string handling functions and the FIND function to locate the delimiters as anchors to extract the constituent attributes. This affords the opportunity for students to also learn other functions such as LEN to determine the number of characters. In finishing this exercise, students may finalise a solution as follows.

```
comma1 =FIND(",",[@address])
comma2 =FIND(",",[@address],[@Comma1]+1)
street =LEFT([@address],[@Comma1]-1)
city =MID([@address],[@Comma1]+2,[@Comma2]-[@Comma1]-2)
state =MID([@address],[@Comma2]+2,2)
zip =RIGHT([@address],5)
```

This approach is helpful for students to apply and enhance their problem-solving and critical-thinking skills. Students will have to actively participate in understanding the rules underlying the transformations needed to split the address attribute into its constituents. They are also positioned to transfer their knowledge and skills to other software environments as needed since they are now familiar with the data-handling patterns and rules.

These concepts can be reinforced through hands-on activities which require students to apply various string handling functions for specific activities (e.g., split the combined name attribute into first name and last name, split the combined name attribute into first name, middle initial, and last name). Extended learning and reinforcement are also possible by designing relevant activities (e.g., create a single formula to split the combined name attribute into first name, middle initial, and last name even when all names may not have a middle initial, which would require the use of the ISERROR function).

The assessment of student learning can then be based on any and all knowledge gained by students through the introduction of concepts or reinforcement activities. Specific questions on the capabilities of the different string handling and other functions, the combination of functions that may be necessary to complete a specific task, and the steps to be followed to find a solution to a given problem are all appropriate to assess student learning.

However, CoPilot accepts a question and describes and summarises the necessary steps. Figure 2 shows the CoPilot response to the question: “How to split an address field into street, city, state, and zip fields using formulas in Excel?” The response by CoPilot shows that students need not engage in reflective thought or critical thinking to find the necessary solution.

⁵ Other data preparation activities such as handling missing values (e.g., the ZIPCODE attribute may be missing values for a set of records), handling inconsistent data (e.g., the STATE attribute may contain the full state name such as “California” or the state code such as “CA”), and embellishing data (e.g., the dataset may not contain a REGION attribute) are also possible, but are not discussed here. These activities allow students to learn features such as VLOOKUP that may further expand their skills.

Figure 2. Microsoft CoPilot response on splitting address attribute into constituents

To split an address field into street, city, state, and ZIP code using formulas in Excel, you can use a combination of functions like LEFT, RIGHT, MID, FIND, and LEN. Here's a step-by-step guide:

Example Address

Let's assume your address is in cell A2 and formatted as "123 Main St, Springfield, IL, 62701".

Extract Street

```
=LEFT(A2, FIND(",", A2) - 1)
```

This formula finds the first comma and extracts everything to the left of it.

Extract City

```
=MID(A2, FIND(",", A2) + 2, FIND(",", A2, FIND(",", A2) + 1) - FIND(",", A2) - 2)
```

This formula finds the first and second commas and extracts the text between them.

Extract State

```
=MID(A2, FIND(",", A2, FIND(",", A2) + 1) + 2, 2)
```

This formula finds the second comma and extracts the two characters after it (assuming the state is always two characters).

Extract ZIP Code

```
=RIGHT(A2, LEN(A2) - FIND(",", A2, FIND(",", A2) + 1) - 4)
```

This formula finds the second comma and extracts everything to the right of it, minus the space and state abbreviation.

Putting It All Together

1. **Street:** =LEFT(A2, FIND(",", A2) - 1)
2. **City:** =MID(A2, FIND(",", A2) + 2, FIND(",", A2, FIND(",", A2) + 1) - FIND(",", A2) - 2)
3. **State:** =MID(A2, FIND(",", A2, FIND(",", A2) + 1) + 2, 2)
4. **ZIP Code:** =RIGHT(A2, LEN(A2) - FIND(",", A2, FIND(",", A2) + 1) - 4)

These formulas should work for addresses in the format "Street, City, State, ZIP". If your addresses have a different format, the formulas might need to be adjusted.

Two additional features⁶ in Excel are also capable of achieving similar results. The first is the "Text to Columns" feature, which provides a wizard interface in which users can indicate the basic parameters, such as the delimiters, that can be used to separate the address attribute into its constituents. No formulas are needed to complete the transformations and students do not have the need to know or understand the operations necessarily. The second is the "Flash Fill" feature that uses principles of pattern matching and AI. For the same transformation problem involving the address attribute, this feature requires students to merely show a few examples of the constituents'

⁶ These are not necessarily GenAI features, but the effect of using these features on teaching and learning is very similar to the effect of using GenAI features as described earlier.

expected results. Flash Fill automatically identifies the rules by which the examples have been determined and applies the same transformations to the remaining rows. This feature hides all complexity in transforming data to such an extent that students are not incentivised to possess knowledge of the operations or apply any problem-solving and critical thinking skills.

Data querying using SQL

Data querying refers to the extraction of relevant data from databases. This is typically accomplished using Structured Query Language (SQL), which is supported by relational database management systems such as Microsoft Access, Oracle, Microsoft SQL Server, and MySQL Server. Specifically, the SELECT statement⁷ is the primary mechanism⁸ by which data can be extracted from database tables.

To help students understand data querying, they need an introduction to: a) tables and attributes, b) primary and foreign keys, c) the inter-relationships between tables in the database, d) conditions and ways to construct compound conditions to restrict data extraction, e) mechanisms to join multiple tables based on inner, left outer, right outer, or full join, f) aggregating computations on necessary attributes using functions such as SUM and AVG, and g) ordering the extracted data in the desired ascending or descending order. Students have the opportunity to learn the different types of reporting supported by the SELECT statement, including projection (i.e., a specific set of columns/ attributes), restriction (i.e., a specific set of rows/ records), aggregation (i.e., group records), and ordering (i.e., arrange records). The SELECT statement's general syntax may be introduced so that students could gain general knowledge of how to apply different features of the SELECT statement for specific requirements.

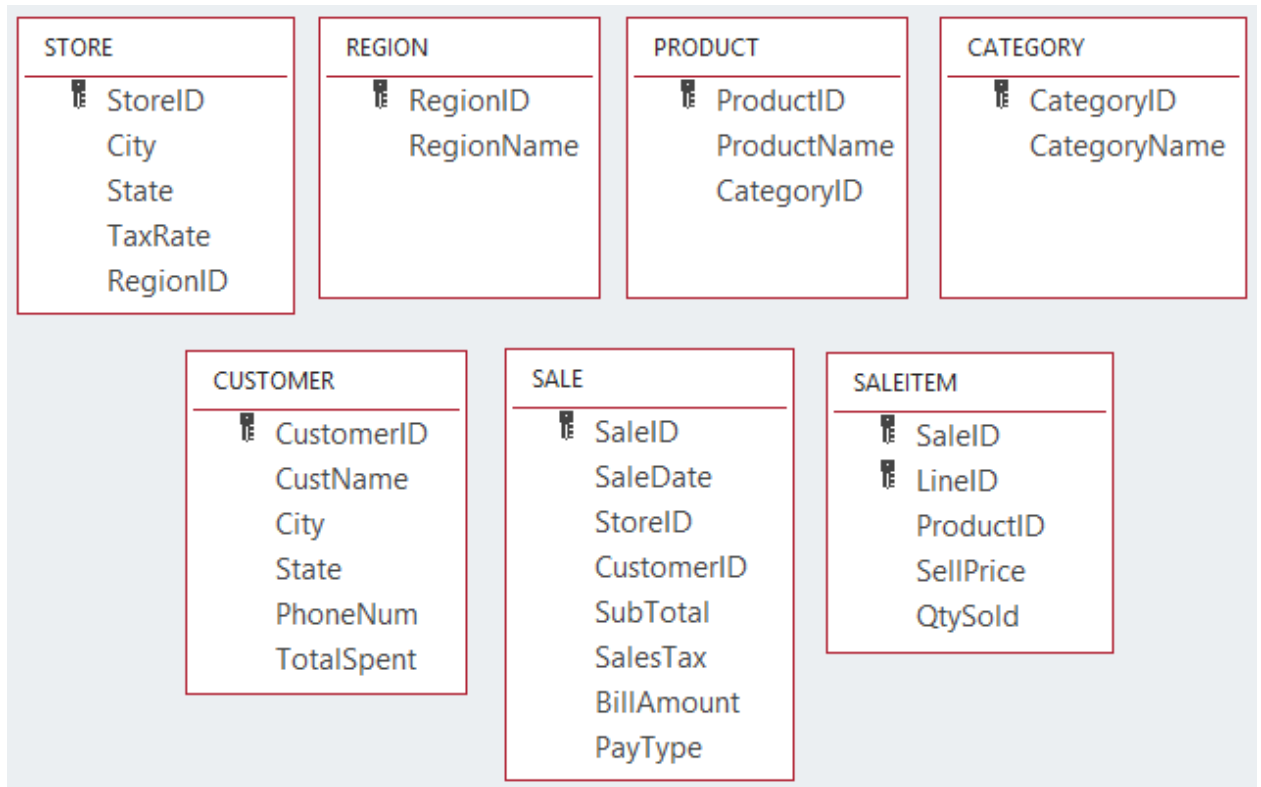
```
SELECT attributes
FROM tables
WHERE join_and/or_restriction_conditions
GROUP BY attributes
HAVING group_conditions
ORDER BY attributes
```

Students can be introduced to relational schemas that show the structure of database tables and the interrelationships, as shown in **Figure 3**. They can learn how to exploit the associations stated by the primary key and foreign key combinations for joining tables and critically reflect on how to extract meaningful reports for business. An analysis of the relational schema shows that: a) the SALE table shares a 1:M relationship with the STORE table through StoreID, b) the REGION table shares a 1:M relationship with the STORE table through RegionID, c) the PRODUCT table shares a 1:M relationship with the PRODUCT table through CategoryID, d) the CUSTOMER table shares a 1:M relationship with the SALE table through CustomerID, and e) the SALE table shares a M:N relationship with the PRODUCT table, which is implemented using two 1:M relationships—the first between the SALE and the SALEITEM tables and the second between the SALEITEM and the PRODUCT tables.

⁷ The SQL system contains other statements for data definition (e.g., CREATE) and data manipulation (e.g., INSERT, DELETE, UPDATE) that are not handled here since the focus is on data extraction.

⁸ There are other mechanisms such as views and stored procedures that can also be implemented in typical database management systems, but they also rely on the SELECT statement.

Figure 3. Relational schema in microsoft access



Examples of business reports may also be discussed: a) find the top 10 most valuable customers (i.e., customers who have spent the most on purchases at store), b) find total sales by year, and c) find the top 10 best-selling products by year. Based on their learning described above, students may develop the following SELECT query to find total sales by geographic region and product category based on the schema in Figure 3.

```
SELECT REGIONNAME, CATEGORYNAME, SUM(SUBTOTAL)
FROM SALE, SALEITEM, PRODUCT, CATEGORY, STORE, REGION
WHERE SALE.SALEID = SALEITEM.SALEID
AND SALEITEM.PRODUCTID = PRODUCT.PRODUCTID
AND PRODUCT.CATEGORYID = CATEGORY.CATEGORYID
AND SALE.STOREID = STORE.STOREID
AND STORE.REGIONID = REGION.REGIONID
GROUP BY REGIONNAME, CATEGORYNAME
ORDER BY REGIONNAME, CATEGORYNAME
```

This SQL SELECT statement combines several capabilities and enables students to use problem solving and critical thinking to determine the solution. Students have to understand the tables and attributes, relationships, join mechanisms, aggregation, and reporting.

The basic principles of data extraction can be further reinforced through hands-on activities that require the use of specific capabilities or need specific reports to be created. For instance, students may be asked to apply functions such as CONCAT (to display a combined name using the first and last names), FORMAT (to display the result in particular formats), and DATEDIFF (to find the time elapsed between two dates). Further, students can also be asked to construct SELECT statements for reports that combine different capabilities. For instance, students could be asked to create a

SELECT statement to find all customers who have spent more than \$1000 over summer (i.e., June to August) during the current year and display their full names and state in alphabetical order of full names by each state.

Student learning can be assessed by questions on various aspects, including the concepts of relational databases (i.e., tables and relationships, primary and foreign keys), the capabilities of the SELECT statement (e.g., what is the purpose of the GROUP BY clause?), the functions that can be used with the SELECT statement (e.g., AVG, CONCAT), the join operations (e.g., when is an outer join appropriate?), and the relational schema (e.g., determine the tables necessary to be joined to obtain a specific report). Students can also be assessed on how to create SELECT statements for particular reports.

However, CoPilot can quickly generate a solution based on a question disrupting the teaching and learning process described above. **Figure 4** shows the CoPilot response to the question: “How to compute the sum of sales transactions by region and category in SQL? The tables are SALE, SALEITEM, PRODUCT, STORE, REGION, and CATEGORY.” CoPilot generated the SELECT statement without information about the attributes and made reasonable assumptions to build expressions such as SUM(Quantity*Price). It also explained the suggested SELECT statement that the instructor would have typically provided in traditional learning. While students may have to tweak the SELECT statement to make it fully compatible with their specific needs or strive to pose more descriptive questions to CoPilot, they really do not have to engage in independent problem solving or critical thinking activities.

Figure 4. Microsoft CoPilot response on querying databases

To compute the sum of sales transactions by region and category, you can use SQL to join the relevant tables and aggregate the sales data. Here's a step-by-step guide and an example query:

1. **Join the tables:** You'll need to join the `SALE`, `SALEITEM`, `PRODUCT`, `STORE`, `REGION`, and `CATEGORY` tables to get the necessary information.
2. **Group by region and category:** Use the `GROUP BY` clause to group the results by region and category.
3. **Sum the sales:** Use the `SUM` function to calculate the total sales.

Here's an example SQL query to achieve this:

```
SELECT
    r.region_name,
    c.category_name,
    SUM(si.quantity * si.price) AS total_sales
FROM
    SALE s
JOIN
    SALEITEM si ON s.sale_id = si.sale_id
JOIN
    PRODUCT p ON si.product_id = p.product_id
JOIN
    STORE st ON s.store_id = st.store_id
JOIN
    REGION r ON st.region_id = r.region_id
JOIN
    CATEGORY c ON p.category_id = c.category_id
GROUP BY
    r.region_name, c.category_name
ORDER BY
    r.region_name, c.category_name;
```

Explanation:

- **Joins:** The query joins the `SALE`, `SALEITEM`, `PRODUCT`, `STORE`, `REGION`, and `CATEGORY` tables to gather all necessary data.
- **SUM:** The `SUM(si.quantity * si.price)` calculates the total sales amount by multiplying the quantity of items sold by their price.
- **GROUP BY:** The results are grouped by `region_name` and `category_name` to get the total sales for each combination.
- **ORDER BY:** The results are ordered by `region_name` and `category_name` for better readability.

Data processing using Python

Data processing refers to the transformation of inputs to outputs as classically defined in computing literature. Several high-level languages such as VB.NET, Visual C#, Java, C++, and Python may be used to create software code for data processing. The inputs may be taken from the user through the keyboard or data files from the computer storage devices. The outputs may be conveyed to the user on the computer display or saved to data files.

To help students learn data processing in Python, they need to be introduced to: a) input and output, b) arithmetic and other operations, c) variables and data structures such as LIST and SET, d) coding statements such as IF and FOR, e) core and other libraries (e.g., pandas), f) pre-defined and user-defined functions, g) properties and methods of objects, and h) data file handling. These may be viewed as building blocks necessary to design a script to accomplish specific tasks effectively. Multiple class sessions with practice activities may be ideal to complete these discussions. Learning the fundamentals of Python and applying problem-solving and critical thinking skills may result in a Python function to compute income tax based on 2023 tax brackets for the state of Ohio as follows.

```
def tax(inc):
    if inc < 26050:
        amt = 0
    elif inc < 100000:
        amt = 360.69 + (inc - 26050) * 0.0275
    elif inc < 115300:
        amt = 2394.32 + (inc - 100000) * 0.03688
    else:
        amt = 2958.58 + (inc - 115300) * 0.0375
    return round(amt)
```

The script highlights knowledge of coding statements (e.g., DEF to define a function, IF and ELIF with ELSE to evaluate conditions, assignment statement, and RETURN to report the computed result), computations with different arithmetic operators, and pre-defined functions: ROUND.

The learning can be extended by requiring the Python function for income tax be used in computing the income tax for incomes earned by citizens. The number of citizens and incomes could be many (e.g., several 1000s) so data files become the better choice for input. This requires students to read data from the files, possibly using the pandas library. Income tax can be computed in different ways, e.g., using the pandas library, unnamed function lambda and list comprehension, or iterative statements such as FOR. The output could also be saved to a data file. These requirements result in a Python script as follows.

```
df = pd.read_csv('incomes.csv')
names = df['last_name'].values.tolist()
incomes = df['nb_income'].values.tolist()
taxes = list(map(lambda x: tax(x), incomes))
records = list(zip(names, incomes, taxes))
df = pd.DataFrame(records, columns=['Name', 'Income', 'Tax'])
df.to_csv('results.csv', index=False)
```

Reinforcement of these concepts can be accomplished through hands-on activities that require students to complete tasks that involve different Python features. For instance, learning activities can be designed to use conditional statements (IF), iterative statements (FOR), assignment statements, arithmetic and conditional expressions, operations using data structures such as lists and set, and methods found in different libraries. Python code for specific requirements such as: defining a function to apply sales discounts based on different tiers to loyalty customers, reading

data from a file and applying computations based on conditions, and searching the data to identify all records that meet specified conditions can also be designed.

The assessment can be based on the knowledge and reinforcement gained by students on using Python to accomplish specific tasks. These could include questions on the purpose of statements such as IF, the appropriateness of data structures such as list for business activities, the use of pre-defined functions, the application of unnamed functions, the MAP comprehension methods, and the specific methods from different libraries that may be appropriate. Students can also be asked to identify the steps (i.e., algorithms) to code for specific business tasks, develop Python code for business tasks with specific capabilities (e.g., the LAMBDA function is required), and alternative ways to support the business tasks using Python.

CoPilot, however, disrupts the learning process by taking a question and providing a description of the data processing steps. Figure 5 shows the CoPilot response to the question: “How to read citizen names and yearly incomes stored in a text datafile, use the income tax function to calculate income taxes for all incomes, and save the citizen names, yearly incomes, and income taxes to another text datafile in python using pandas?” The response by CoPilot shows that students may not need to learn Python and the fundamental building blocks of scripting but can find the necessary solution. Some level of customisation is needed to make the code for income tax function to match the 2023 Ohio income tax computations, but the rest of the script could be used as is to achieve the necessary results.

Figure 5. Microsoft CoPilot response on computing income tax

Sure, I can help you with that! Here's a step-by-step guide to achieve this using Python and pandas:

1. **Read the data from the text file:**
 - o Assume the text file is formatted with each line containing a citizen's name and yearly income separated by a comma.
2. **Load the data into lists:**
 - o Use pandas to read the data into a DataFrame and then convert it to lists.
3. **Calculate income taxes:**
 - o Define an income tax function and apply it to the yearly incomes.
4. **Save the results to another text file:**
 - o Write the DataFrame with the calculated taxes to a new text file.

Here's a sample code to illustrate these steps:

```
import pandas as pd

# Step 1: Read the data from the text file
input_file = 'citizens.txt'
data = pd.read_csv(input_file, header=None, names=['Name', 'Income'])

# Step 2: Load the data into lists
names = data['Name'].tolist()
incomes = data['Income'].tolist()

# Step 3: Define the income tax function
def calculate_tax(income):
    # Example tax calculation (you can adjust this as needed)
    if income <= 10000:
        return 0
    elif income <= 50000:
        return income * 0.1
    else:
        return income * 0.2

# Apply the tax function to the incomes
data['Tax'] = data['Income'].apply(calculate_tax)

# Step 4: Save the results to another text file
output_file = 'citizens_with_taxes.txt'
data.to_csv(output_file, index=False, header=True)

print("Data with taxes saved to", output_file)
```

RETHINKING TEACHING AND LEARNING

The foregoing illustrations of the traditional teaching and learning methods across the engagement, reinforcement, and assessment stages contrasted with the use of GenAI tools in the three different contexts are summarised in Table 1.

Table 1. Summary of traditional teaching and learning

Context	Engagement	Reinforcement	Assessment
Data preparation using Excel	String handling functions such as LEFT, RIGHT, MID, and FIND	Activities that require the use of string-handling functions Extensions with functions such as ISERROR and ISNULL	Knowledge of string handling functions and how to apply them
Data querying using SQL	SQL SELECT statement and its features such as WHERE and GROUP BY Join operations based on INNER, LEFT, RIGHT, and FULL Aggregation functions such as SUM, AVG, COUNT, MAX, and MIN	Activities that require use of projection, restriction, and aggregation Activities that require use of grouping and ordering by attributes	Knowledge of table operations Knowledge of features in SELECT statement Knowledge of how to use SELECT statement for specific reports
Data processing using Python	Variables and data structures such as LIST and SET Statements such as IF, DEF, and FOR Pre-defined, user-defined, and unnamed functions Methods for data structures such as Append for LIST Libraries such as pandas and numpy	Activities that require use of specific types of variables or data structures Activities that require use of specific statements such as IF and FOR Activities that require use of specific pre-defined or user-defined functions	Knowledge of data structures such as LIST Knowledge of coding statements and their use Knowledge of how to define and use functions

The traditional teaching and learning approaches over the multiple stages generate considerable value for students. They have opportunities to gain knowledge, develop skills, and demonstrate learning through the stages of engagement, reinforcement, and assessment. As shown in each of the three contexts, students have opportunities to apply and enhance problem-solving and critical-thinking skills. However, the use of GenAI tools runs counter to traditional approaches in that students could use them to quickly find solutions without having to expend much effort thinking through overall strategies or particular steps to solve problems. It is possible that excessive reliance on GenAI tools could come at the expense of learning and intellectual growth in students. While GenAI tools may quickly satisfy immediate requirements⁹, students may find their lifelong learning skills and abilities severely curtailed in long run when relying on GenAI tools. Further, it is not possible for instructors to really reinforce or assess student learning since GenAI tools can be used to obtain solutions for any problems or activities given to students. It is also unclear what can be reinforced or assessed.

⁹ This discussion assumes that GenAI tools provide the correct solutions. However, the possibility remains that GenAI tools may not produce the results desired by students. There is considerable evidence that GenAI tools may hallucinate and provide erroneous solutions (e.g., Hicks et al. 2024). In such situations, students may have to fall back on their own skills and abilities rather than relying on GenAI tools to solve problems.

Figure 6 compares traditional and GenAI methods using a set of criteria. It can be seen that GenAI tools become the source of knowledge supplanting instructors due to their ability to not only provide solutions to questions but also how-to and why-so explanations leading to task completion. If GenAI tools can provide solutions and explanations, questions about the need and role of the engagement, reinforcement, and assessment stages can be raised. Instructors may no longer need to be the source of knowledge or be responsible for reinforcing student learning. The assessment of student learning is also questionable since it is unclear what instructors can really assess when GenAI tools help students complete the tasks.

Figure 6. Comparison of traditional vs. GenAI

Criterion	Traditional	<<< Blended >>>	GenAI
Source of knowledge	Instructor		Software
Need for engagement stage activities	High	If GenAI tools are here to stay and are expected to be used by students, are there opportunities to exploit blended learning that combines traditional and GenAI methods?	Low
Role of reinforcement stage activities	High		Low
Role of assessment stage activities	High		Low
Need for student critical thinking	High		Low
Need for student problem solving	High		Low
Possibility of student lifelong learning	High		Low
Speed of task completion	Slow		Fast

Suppose GenAI tools are here to stay and are expected to be used by students (especially for completing out-of-class assignments without instructor oversight). In that case, the notion of “blended” methods arises when the learning methods are viewed on a continuum from traditional to GenAI methods. The fundamental question then is whether there are opportunities to exploit blended learning that combines traditional and GenAI methods. From an instructor’s perspective, developing interventions for student learning and engagement with critical thinking and problem-solving activities becomes challenging and redundant when GenAI tools are widely available and easily accessible. For instance, instructors may require students to first complete activities on their own and then complete the same activities using GenAI tools such that they can discern the role and possibilities of GenAI tools. Instructors may have to find creative ways to either disengage students from relying extensively on GenAI tools or motivate students to apply their own problem-solving and critical thinking skills beyond using GenAI tools. For instance, instructors could ask students to develop solutions using GenAI tools that they can compare against a correct solution such that they can develop an understanding of their own skills and learning along with the advantages and limitations of GenAI tools. Students could be encouraged to focus on lifelong learning skills even when they may be interested in taking advantage of GenAI tools to complete their tasks. The responsible use of GenAI tools blended with the foundational principles of traditional teaching and learning could be a potential long-term solution for sustaining business education that shapes students to be successful professionals and contributors to society.

CONCLUSION

The availability of GenAI tools has raised challenges for traditional teaching and learning since they allow students to bypass problem-solving and critical thinking requirements to complete tasks. While GenAI tools may be helpful in certain conditions, exclusive or excessive reliance on such

capabilities may undermine individuals' intellectual growth and well-being (first as students and then as professionals) within society in the long run. Traditional teaching and learning methods may have to be "blended" with GenAI tools so that students will be equipped with problem-solving, critical thinking, and lifelong learning skills to influence and shape society in the future.

There are several opportunities for future research. First, the research could examine the extent to which the use of GenAI tools impacts problem-solving and critical thinking. Preliminary calls and research in these domains have also been raised (Boussioux et al. 2024; Larson et al. 2024) to help set the agenda. Second, research on how GenAI tools impact individuals' intellectual growth and well-being would be beneficial. This is because there is the possibility that individuals may feel a loss of control and self-worth when activities based on human thought are completed mainly by GenAI tools (Caporusso, 2023). Finally, research could examine optimal ways to enable blended methods that incorporate traditional and GenAI methods. This could involve different mechanisms such as designing activities for students to engage with GenAI tools for specific activities or over an entire semester and reflect on the learning experience (Acar 2023; Hyde et al. 2023). The engagement-reinforcement-assessment framework can help instructors design interventions that balance the traditional norms of learning and the capabilities of GenAI tools.

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